CHAPTER 4

AUTOMOTIVE CLUTCHES, TRANSMISSIONS, AND TRANSAXLES

INTRODUCTION

Learning Objective: State the operating principles and identify the components and the maintenance for a clutch, a manual transmission, an automatic transmission, and a transaxle.

In a vehicle, the mechanism that transmits the power developed by the engine to the wheels and/or tracks and accessory equipment is called the **power train.** In a simple application, such as a stationary engine-powered hoist, a set of gears or a chain and sprocket could perform this task. However, automotive and construction equipment are not designed for such simple operating conditions. They are designed to provide pulling power, to move at high speeds, to travel in reverse as well as forward, and to operate on rough terrain as well as smooth roads. To meet these varying conditions, vehicle power trains are equipped with a variety of components. This chapter discusses the basic automotive clutch, transmissions (manual and automatic), and transaxles (manual and automatic).

AUTOMOTIVE CLUTCHES

Learning Objective: State the operating principles and identify the components and maintenance requirements for an automotive clutch.

An automotive clutch is used to connect and disconnect the engine and manual (hand-shifted) transmission or transaxle. The clutch is located between the back of the engine and the front of the transmission.

With a few exceptions, the clutches common to the Naval Construction Force (NCF) equipment are the single-, double-, and multiple-disc types. The clutch that you will encounter the most is the single-disc type, as shown in figure 4-1. The double-disc clutch (fig. 4-2) is substantially the same as the single disc, except that another driven disc and an intermediate driving plate are added. This clutch is used in heavy-duty vehicles and construction equipment. The multiple-disc clutch is used in the automatic transmission and for the steering clutch used in tracked equipment.

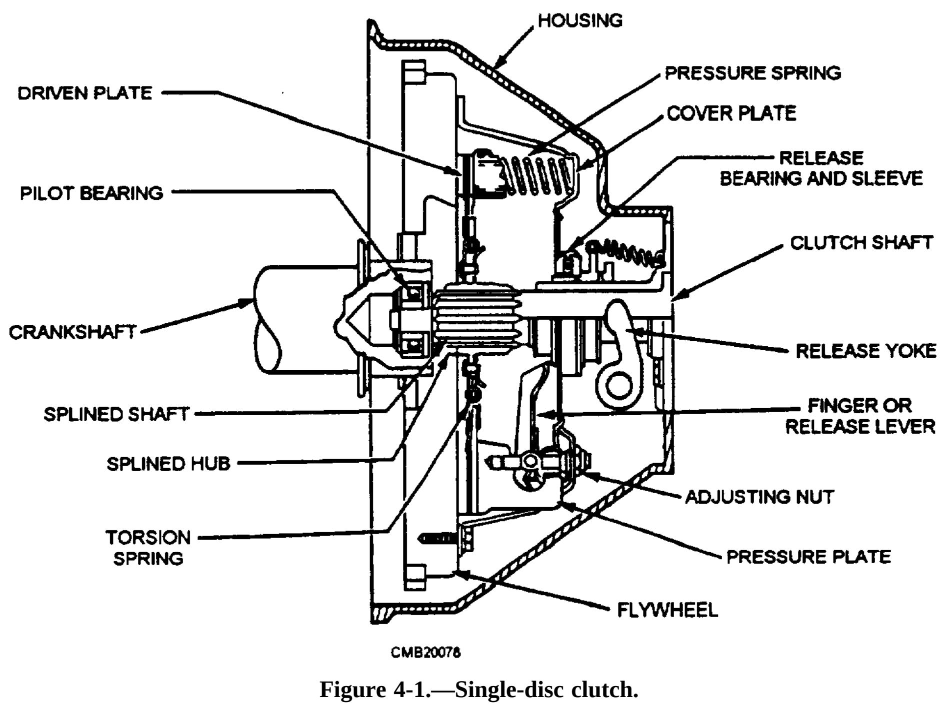

Figure 4-1.—Single-disc clutch.

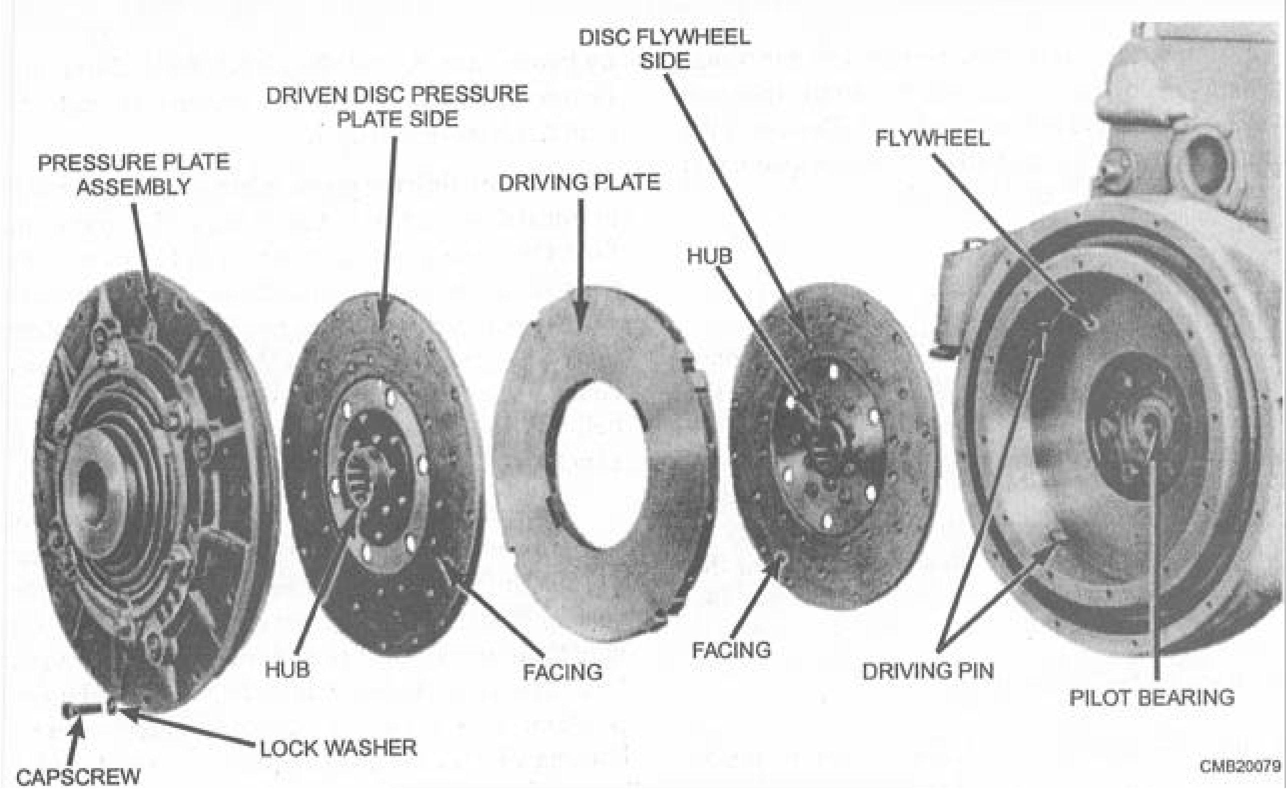

Figure 4-2.—Double-disc clutch, exploded view.

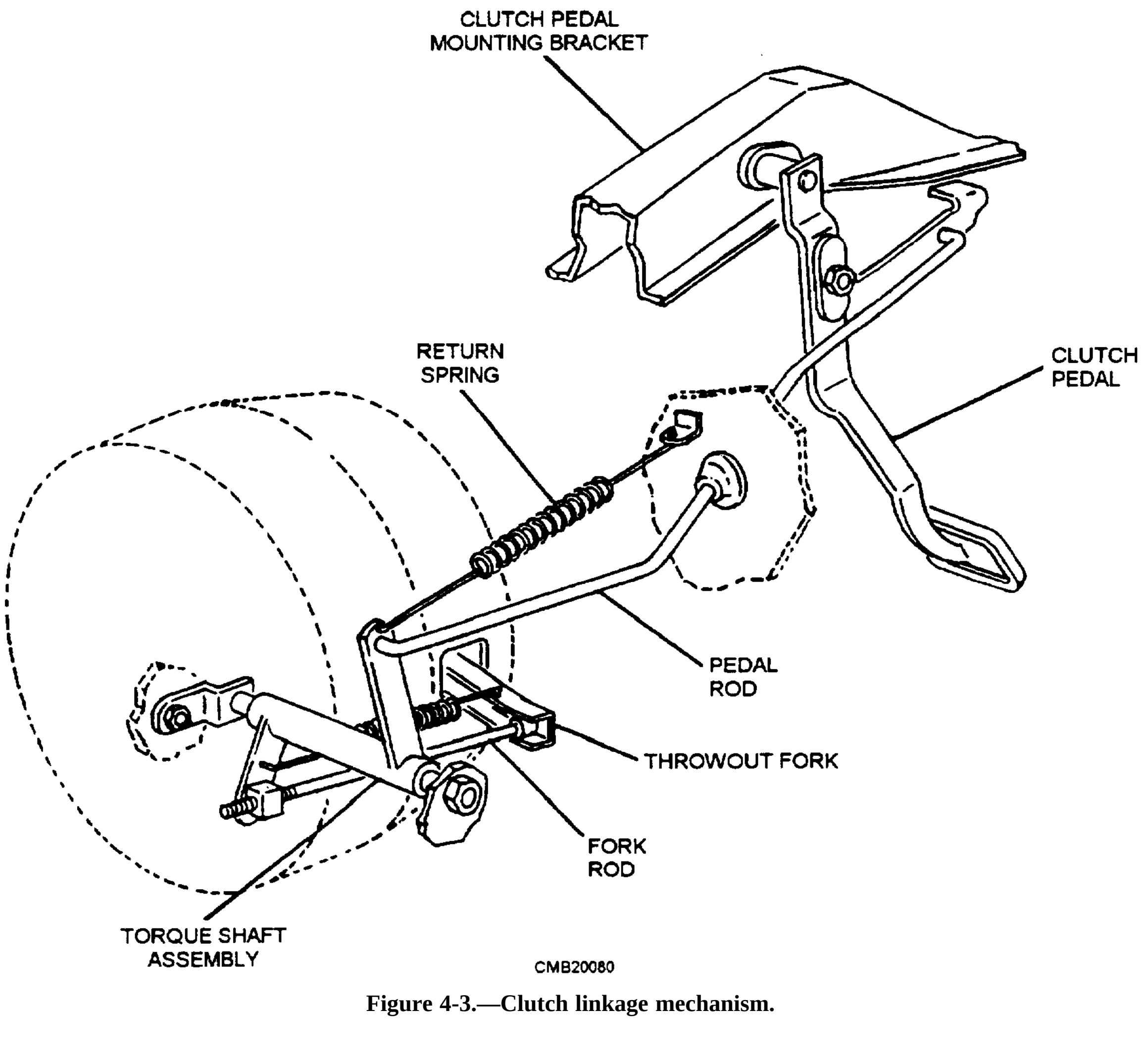

Figure 4-3.—Clutch linkage mechanism.

The operating principles, component functions, and maintenance requirements are essentially the same for each of the three clutches mentioned. This being the case, the single-disc clutch will be used to acquaint you with the fundamentals of the clutch.

CLUTCH CONSTRUCTION

The clutch is the first drive train component powered by the engine crankshaft. The clutch lets the driver control power flow between the engine and the transmission or transaxle. Before understanding the operation of a clutch, you must first become familiar with the parts and their function. This information is very useful when learning to diagnose and repair the clutch assembly.

Clutch Release Mechanism

A clutch release mechanism allows the operator to operate the clutch. Generally, it consists of the clutch pedal assembly, either mechanical linkage, cable, or hydraulic circuit, and the clutch fork. Some manufacturers include the release bearing as part of the clutch release mechanism.

A **clutch linkage mechanism** uses levers and rods to transfer motion from the clutch pedal to the clutch fork. One configuration is shown in figure 4-3. When the pedal is pressed, a pushrod shoves on the bell crank and the bell crank reverses the forward movement of the clutch pedal. The other end of the bell crank is connected to the release rod. The release rod transfers bell crank movement to the clutch fork. It also provides a method of adjustment for the clutch.

The **clutch cable mechanism** uses a steel cable inside a flexible housing to transfer pedal movement to the clutch fork. As shown in figure 4-4, the cable is usually fastened to the upper end of the clutch pedal, with the other end of the cable connecting to the clutch fork. The cable housing is mounted in a stationary position. This allows the cable to slide inside the housing whenever the clutch pedal is moved. One end of the clutch cable housing has a threaded sleeve for clutch adjustment.

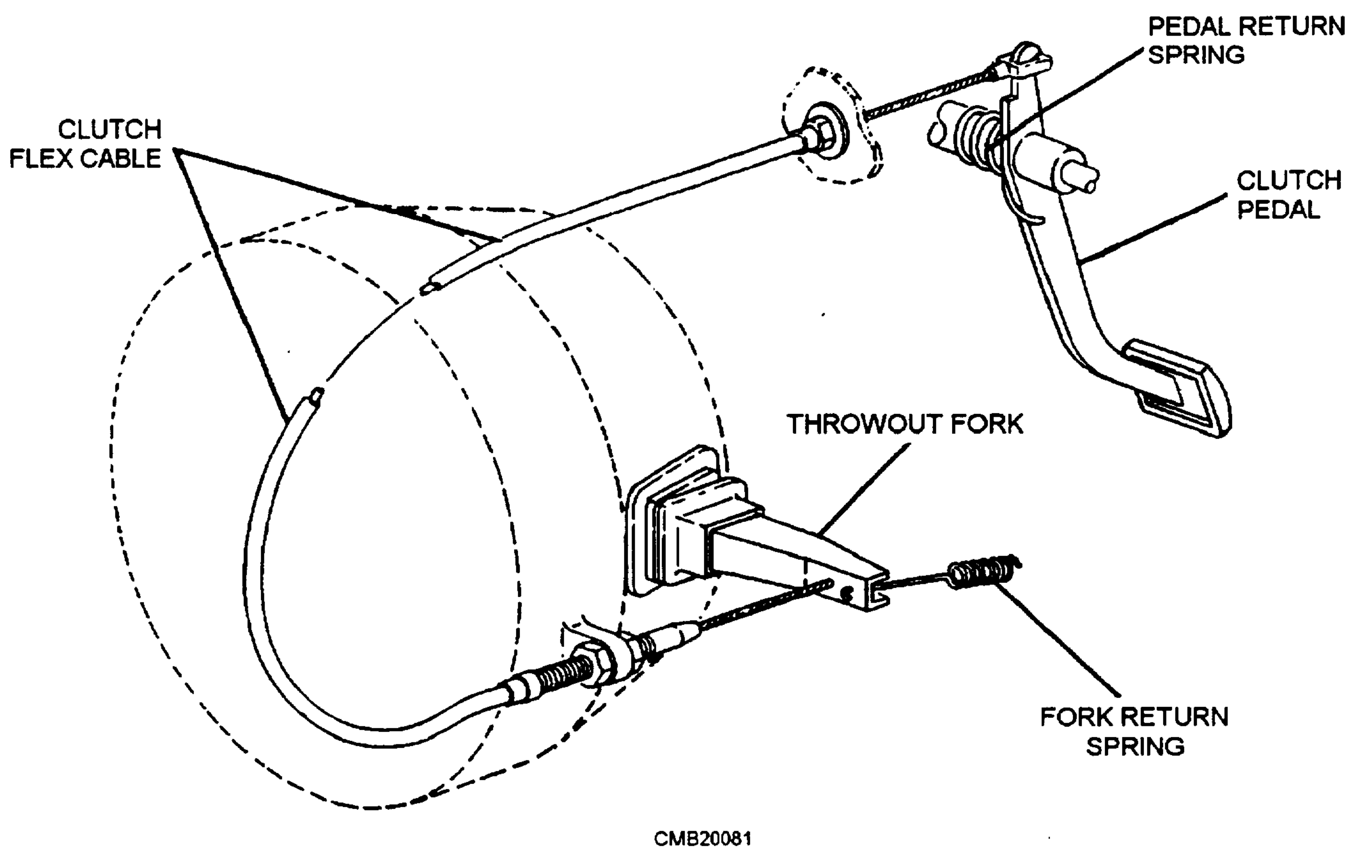

Figure 4-4.—Clutch cable mechanism.

A **hydraulic clutch release mechanism** (fig. 4-5) uses a simple hydraulic circuit to transfer clutch pedal action to the clutch fork. It has three basic parts—master cylinder, hydraulic lines, and a slave cylinder.

Movement of the clutch pedal creates hydraulic pressure in the master cylinder, which actuates the slave cylinder. The slave cylinder then moves the clutch fork.

Clutch Fork

The clutch fork, also called a clutch arm or release arm, transfers motion from the release mechanism to the release bearing and pressure plate. The clutch fork sticks through a square hole in the bell housing and mounts on a pivot. When the clutch fork is moved by the release mechanism, it PRIES on the release bearing to disengage the clutch.

A rubber boot fits over the clutch fork. This boot is designed to keep road dirt, rocks, oil, water, and other debris from entering the clutch housing.

Clutch Housing

The clutch housing is also called the bell housing. It bolts to the rear of the engine, enclosing the clutch assembly, with the manual transmission bolted to the back of the housing. The lower front of the housing has a metal cover that can be removed for fly-wheel ring gear inspection or when the engine must be separated from the clutch assembly. A hole is provided in the side of the housing for the clutch fork. It can be made of aluminum, magnesium, or cast iron.

Release Bearing

The release bearing, also called the throw-out bearing, is a ball bearing and collar assembly. It reduces friction between the pressure plate levers and the release fork. The release bearing is a sealed unit pack with a lubricant. It slides on a hub sleeve extending out from the front of the manual transmission or transaxle.

The release bearing snaps over the end of the clutch fork. Small spring clips hold the bearing on the fork. Then fork movement in either direction slides the release bearing along the transmission hub sleeve.

Pressure Plate

The pressure plate is a spring-loaded device that can either engage or disengage the clutch disc and the flywheel. It bolts to the flywheel. The clutch disc fits

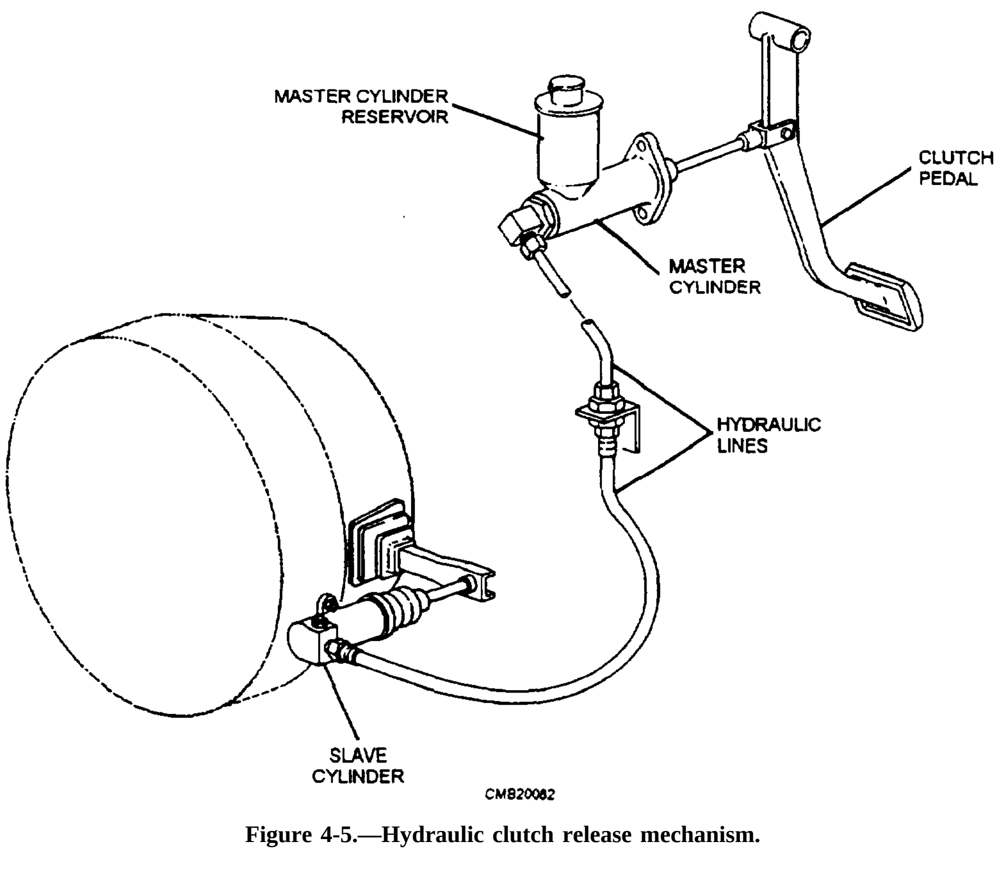

Figure 4-5.—Hydraulic clutch release mechanism.

between the flywheel and the pressure plate. There are two types of pressure plates—the coil spring type and the diaphragm type.

Coil spring pressure plate uses small coil springs similar to valve springs (fig. 4-6). The face of the pressure plate is a large, flat ring that contacts the clutch disc during clutch engagement. The backside of the pressure plate has pockets for the coil springs and brackets for hinging the release levers. During clutch action, the pressure plate moves back and forth inside the clutch cover. The release levers are hinged inside the pressure plate to pry on and move the pressure plate face away from the clutch disc and flywheel. Small clip-type springs fit around the release levers to keep them rattling when fully released. The pressure plate cover fits over the springs, the release levers, and the pressure plate face. Its main purpose is to hold the assembly together. Holes around the outer edge of the cover are for bolting the pressure plate to the flywheel.

Diaphragm pressure plate (fig. 4-7) uses a single diaphragm spring instead of coil springs. This type of pressure plate functions similar to that of the coil spring type. The diaphragm spring is a large, round disc of spring steel. The spring is bent or dished and has pie-shaped segments running from the outer edge to the center. The diaphragm spring is mounted in the pressure plate with the outer edge touching the back of the pressure plate face. The outer rim of the diaphragm is secured to the pressure plate and is pivoted on rings (pivot rings) approximately 1 inch from the outer edge.

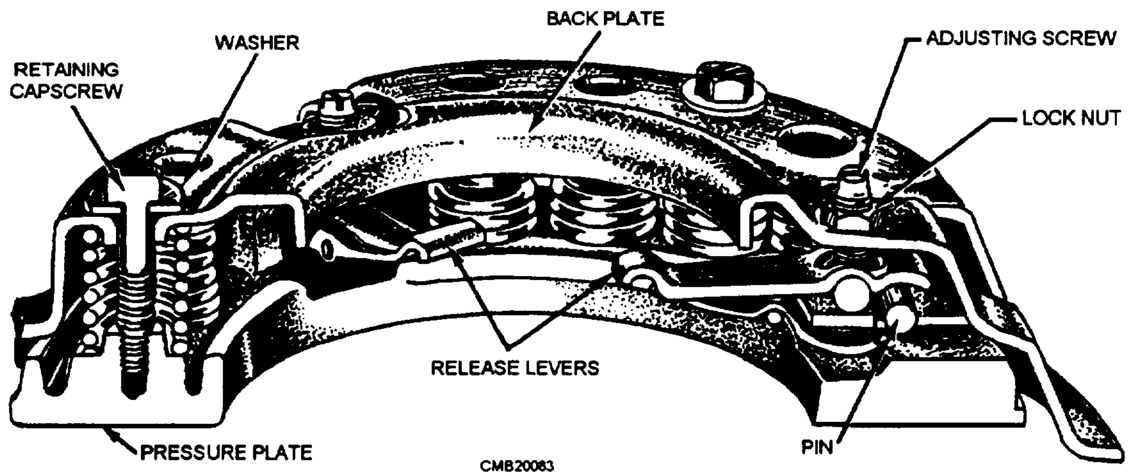

Figure 4-6.—Coil spring pressure plate.

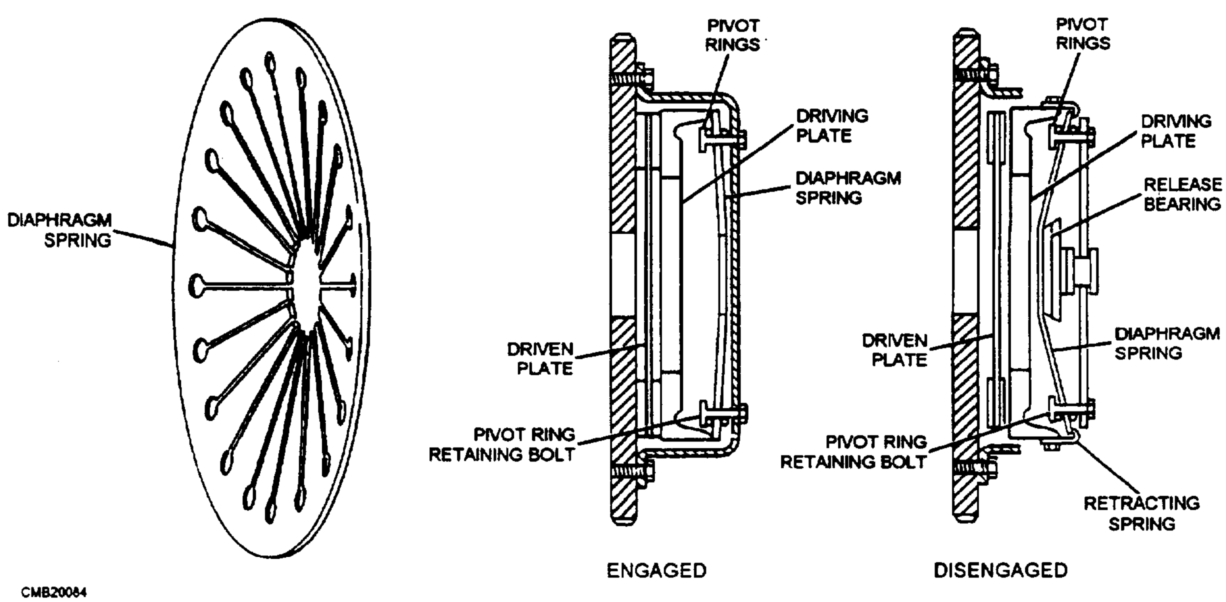

Figure 4-7.—Diaphragm pressure plate operation.

Application of pressure at the inner section of the diaphragm will cause the outer rim to move away from the flywheel and draw the pressure plate away from the clutch disc, disengaging the clutch.

Clutch Disc

The clutch disc, also called friction lining, consists of a splined hub and a round metal plate covered with friction material (lining). The splines in the center of the clutch disc mesh with the splines on the input shaft of the manual transmission. This makes the input shaft and disc turn together. However, the disc is free to slide back and forth on the shaft.

Clutch disc **torsion springs,** also termed **damping springs,** absorb some of the vibration and shock produced by clutch engagement. They are small coil springs located between the clutch disc splined hub and the friction disc assembly. When the clutch is engaged, the pressure plate jams the stationary disc against the spinning flywheel. The torsion springs compress and soften, as the disc first begins to turn with the flywheel.

Clutch disc **facing springs,** also called the **cushioning springs,** are flat metal springs located under the friction lining of the disc. These springs have a slight wave or curve, allowing the lining to flex inward slightly during initial engagement. This also allows for smooth engagement.

The clutch disc **friction material,** also called **disc lining** or **facing,** is made of heat-resistant asbestos, cotton fibers, and copper wires woven or molded together. Grooves are cut into the friction material to aid cooling and release of the clutch disc. Rivets are used to bond the friction material to both sides of the metal body of the disc.

Flywheel

The flywheel is the mounting surface for the clutch. The pressure plate bolts to the flywheel face. The clutch disc is clamped and held against the flywheel by the spring action of the pressure plate. The face of the flywheel is precision machined to a smooth surface. The face of the flywheel that touches the clutch disc is made of iron. Even if the flywheel were aluminum, the face is iron because it wears well and dissipates heat better.

Pilot Bearing

The pilot bearing or bushing is pressed into the end of the crankshaft to support the end of the transmission input shaft. The pilot bearing is a solid bronze bushing, but it also may be a roller or ball bearing.

The end of the transmission input shaft has a small journal machined on its end. This journal slides inside the pilot bearing. The pilot bearing prevents the transmission shaft and clutch disc from wobbling up and down when the clutch is released. It also assists the input shaft center the disc on the flywheel.

CLUTCH OPERATION

When the operator presses the clutch pedal, the clutch release mechanism pulls or pushes on the clutch release lever or fork (fig. 4-8). The fork moves the release bearing into the center of the pressure plate, causing the pressure plate to pull away from the clutch disc releasing the disc from the flywheel. The engine crankshaft can then turn without turning the clutch disc and transmission input shaft.

When the operator releases the clutch pedal, spring pressure inside the pressure plate pushes forward on the clutch disc (fig. 4-8). This action locks the

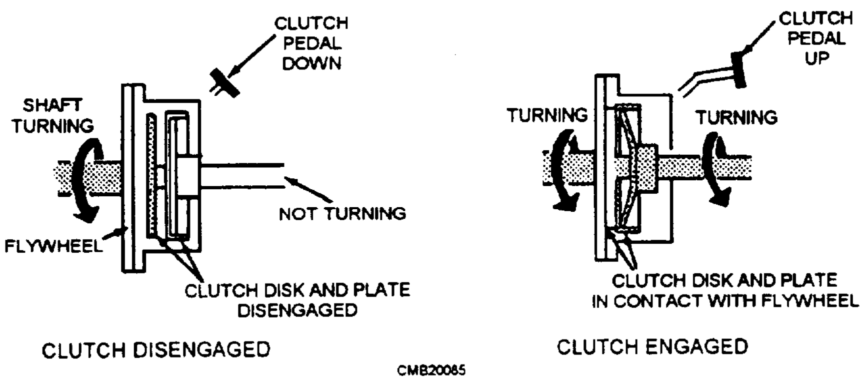

Figure 4-8.—Clutch operation.

flywheel, the clutch disc, the pressure plate, and the transmission input shaft together. The engine again rotates the transmission input shaft, the transmission gears, the drive train, and the wheels of the vehicle.

CLUTCH START SWITCH

Many of the newer vehicles incorporate a clutch start switch into the starting system. The clutch start switch is mounted on the clutch pedal assembly. The clutch start switch prevents the engine from cranking unless the clutch pedal is depressed fully. This serves as a safety device that keeps the engine from possibly starting while in gear. Wires from the ignition switch feeds starter solenoid current through the switch. Unless the switch is closed (clutch pedal depressed), the switch prevents current from reaching the starter solenoid. With the transmission in neutral, the clutch start switch is bypassed so the engine will crank and start.

CLUTCH ADJUSTMENT

Clutch adjustments are made to compensate for wear of the clutch disc lining and linkage between the clutch pedal and the clutch release lever. This involves setting the correct amount of free play in the release mechanism. Too much free play causes the clutch to drag during clutch disengagement. Too little free play causes clutch slippage. It is important for you to know how to adjust the three types of clutch release mechanisms.

Clutch Linkage Adjustment

Mechanical clutch linkage is adjusted at the release rod going to the release fork (fig. 4-9). One end of the release rod is threaded. The effective length of the rod can be increased to raise the clutch pedal (decrease free travel). It can also be shortened to lower the clutch pedal (increase free travel).

To change the clutch adjustment, loosen the release rod nuts. Turn the release rod nuts on the threaded rod until you have reached the desired free pedal travel.

Clutch Cable Adjustment

Like the mechanical linkage, a clutch cable adjustment may be required to maintain the correct pedal height and free travel. Typically the clutch cable will have an adjusting nut. When the nut is turned, the length of the cable housing increases or decreases. To increase clutch pedal free travel, turn the clutch cable housing nut to shorten the housing, and, to decrease

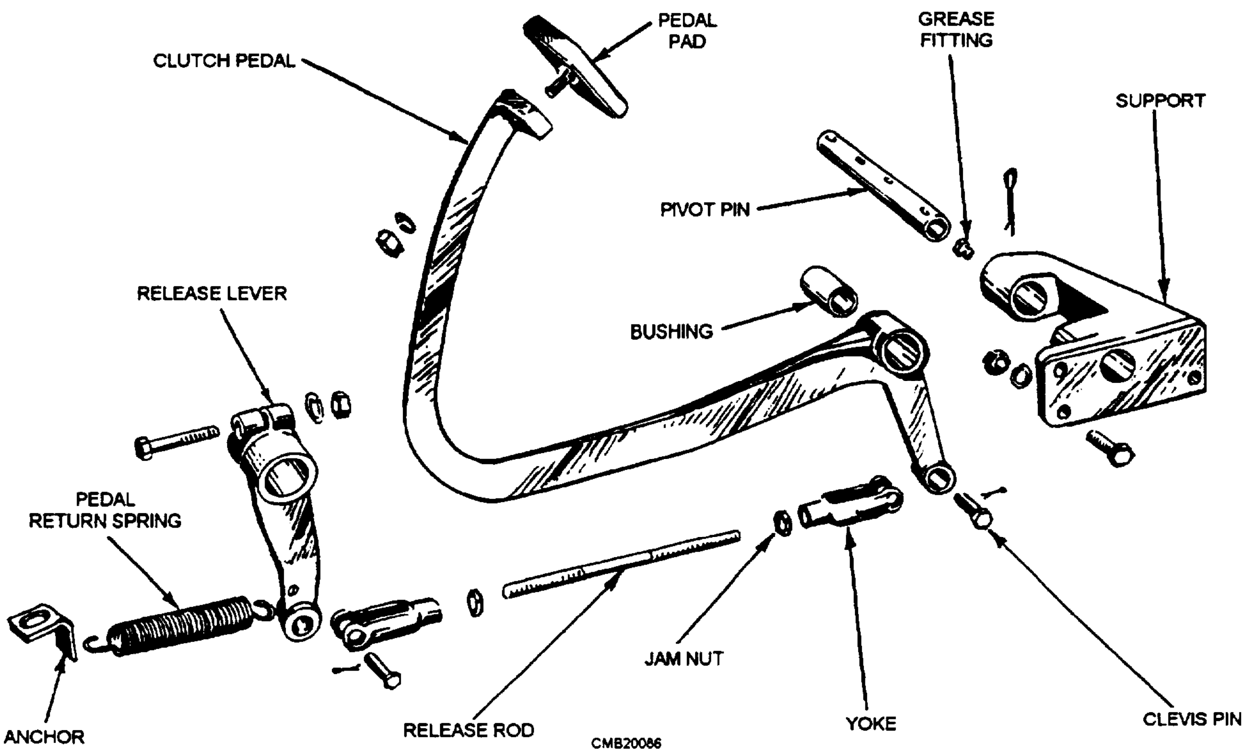

Figure 4-9.—Clutch pedal and linkage.

clutch pedal free travel, turn the nut to lengthen the housing.

Hydraulic Clutch Adjustment

The hydraulically operated clutch shown in figure 4-10 is adjusted by changing the length of the slave cylinder pushrod. To adjust a hydraulic clutch, simply turn the nut or nuts on the pushrod as needed.

NOTE

When a clutch adjustment is made, refer to the manufacturer's service manual for the correct method of adjustment and clearance. If no manuals are available, an adjustment that allows 1 1/2 inches of clutch pedal free travel will allow adequate clutch operation until the vehicle reaches the shop and manuals are available.

CLUTCH TROUBLESHOOTING

An automotive clutch normally provides dependable service for thousands of miles. However, stop and go traffic will wear out a clutch quicker than highway driving. Everytime a clutch is engaged, the clutch disc and other components are subjected to considerable heat, friction, and wear.

Operator abuse commonly causes premature clutch troubles. For instance, "riding the clutch"

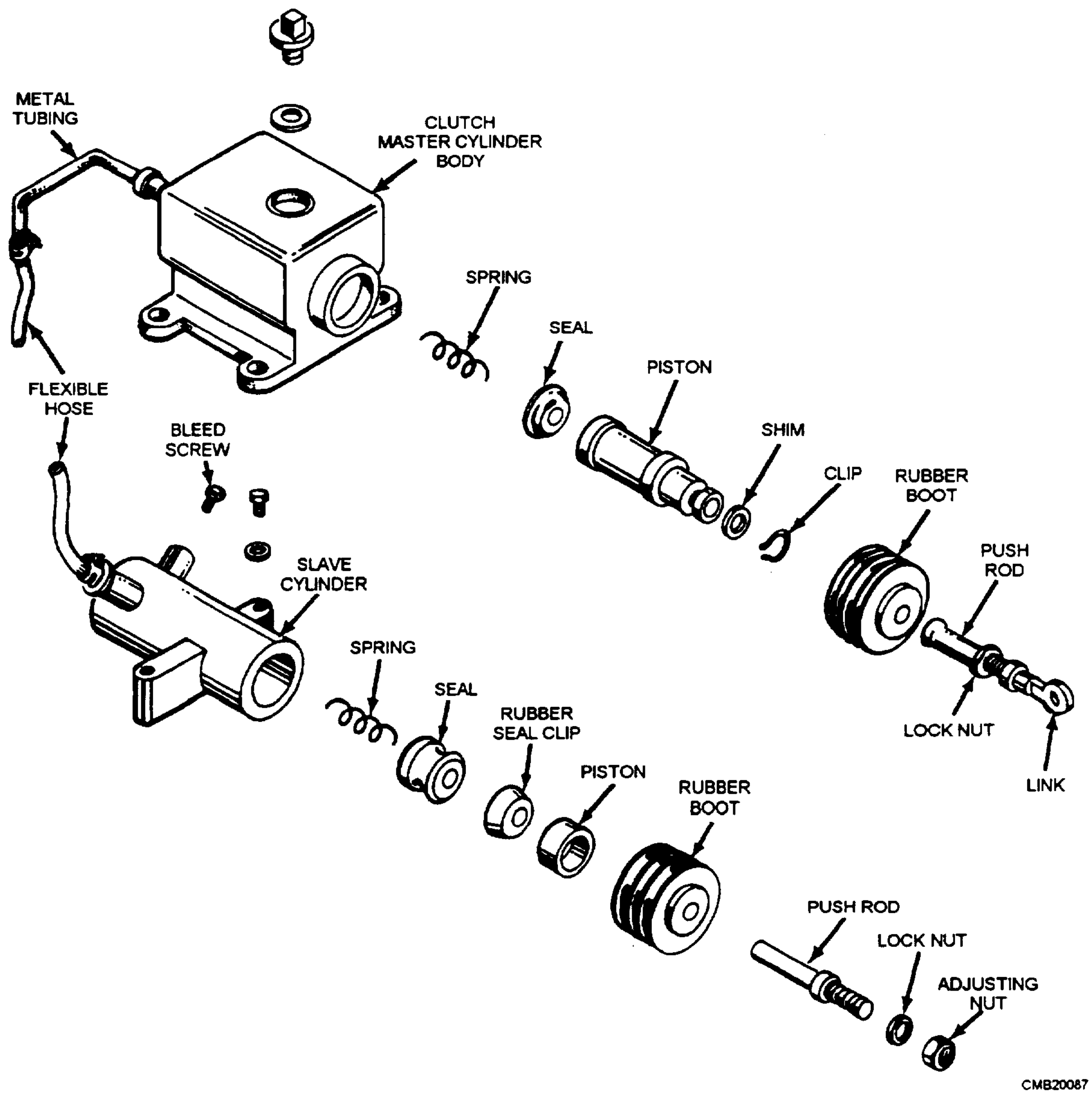

Figure 4-10.—Master cylinder, slave cylinder, and connections for a typical hydraulic clutch.

(overslipping clutch upon acceleration), resting your foot on the clutch pedal while driving, and other driving errors can cause early clutch failure.

When a vehicle enters the shop for clutch troubles, you should test-drive the vehicle. While the vehicle is being test-driven, you should

- check the action of the clutch pedal,
- listen for unusual noises, and
- feel for clutch pedal vibrations.

Gather as much information as you can on the operation of the clutch. Use this information, your knowledge of clutch principles, and a service manual-troubleshooting chart to determine which components are faulty.

There are five types of clutch problems—slipping, grabbing, dragging, abnormal noises, and vibration. It is important to know the symptoms produced by these problems and the parts that might be the cause.

Slipping

Slipping occurs when the driven disc fails to rotate at the same speed as the driving members when the clutch is fully engaged. This condition results whenever the clutch pressure plate fails to hold the disc tight against the face of the flywheel. If clutch slippage is severe, the engine speed will rise rapidly on acceleration, while the vehicle gradually increases in speed. Slight but continuous slippage may go unnoticed until the clutch facings are ruined by excessive temperature caused by friction.

Normal wear of the clutch lining causes the free travel of the clutch linkage to decrease, creating the need for adjustment. Improper clutch adjustment can cause slippage by keeping the release bearing in contact with the pressure plate in the released position. Even with your foot off the pedal, the release mechanism will act on the clutch fork and release bearing.

Some clutch linkages are designed to allow only enough adjustment to compensate for the lining to wear close to the rivet heads. This prevents damage to the flywheel and pressure plate by the rivets wearing grooves in their smooth surfaces.

Other linkages will allow for adjustment after the disc is worn out. When in doubt whether the disc is worn excessively, remove the inspection cover on the clutch housing and visually inspect the disc.

Binding linkage prevents the pressure plate from exerting its full pressure against the disc, allowing it to slip. Inspect the release mechanism for rusted, bent, misaligned, sticking, or damaged components. Wiggle the release fork to check for free play. These problems result in slippage.

A broken motor mount (engine mount) can cause clutch slippage by allowing the engine to move, binding the clutch linkage. Under load, the engine can lift up in the engine compartment, shifting the clutch linkage and pushing on the release fork.

Grease and oil on the disc will also cause slippage. When this occurs, locate and stop any leakage, thoroughly clean the clutch components, and replace the clutch disc. This is the only remedy.

If clutch slippage is **NOT** caused by a problem with the clutch release mechanism, then the trouble is normally inside the clutch. You have to remove the transmission and clutch components for further inspection. Internal clutch problems, such as weak springs and bent or improperly adjusted release levers, will prevent the pressure plate from applying even pressure. This condition allows the disc to slip.

To test the clutch for slippage, set the emergency brake and start the engine. Place the transmission or transaxle in high gear. Then try to drive the vehicle forward by slowly releasing the clutch pedal. A clutch in good condition should lock up and immediately kill the engine. A badly slipping clutch may allow the engine to run, even with the clutch pedal fully released. Partial clutch slippage could let the engine run momentarily before stalling.

NOTE

Never let a clutch slip for more than a second or two. The extreme heat generated by slippage will damage the flywheel and pressure plate faces.

Grabbing

A grabbing or chattering clutch will produce a very severe vibration or jerking motion when the vehicle is accelerated from a standstill. Even when the operator slowly releases the clutch pedal, it will seem like the clutch pedal is being pumped rapidly up and down. A loud bang or chattering may be heard, as the vehicle body vibrates.

Clutch grabbing and chatter is caused by problems with components inside the clutch housing (friction disc, flywheel, or pressure plate). Other reasons for a grabbing clutch could be due to oil or grease on the disc facings, glazing, or loose disc facings. Broken parts in the clutch, such as broken disc facings, broken facing springs, or a broken pressure plate, will also cause grabbing.

There are several things outside of the clutch that will cause a clutch to grab or chatter when it is being engaged. Loose spring shackles or U-bolts, loose transmission mounts, and worn engine mounts are among the items to be checked. If the clutch linkage binds, it may release suddenly to throw the clutch into quick engagement, resulting in a heavy jerk. However, if all these items are checked and found to be in good condition, the trouble is inside the clutch itself and will have to be removed for repair.

Dragging

A dragging clutch will make the transmission or transaxle grind when trying to engage or shift gears. This condition results when the clutch disc does not completely disengage from the flywheel or pressure plate when the clutch pedal is depressed. As a result, the clutch disc tends to continue turning with the engine and attempts to drive the transmission.

The most common cause of a dragging clutch is too much clutch pedal free travel. With excessive free travel, the pressure plate will not fully release when the clutch pedal is pushed to the floor. Always check the clutch adjustments first. If adjustment of the linkage does not correct the trouble, the problem is in the clutch, which must be removed for repair.

On the inside of the clutch housing, you will generally find a warped disc or pressure plate, oil or grease on the friction surface, rusted or damaged transmission input shaft, or improper adjustment of the pressure plate release levers causing the problem.

Abnormal Noises

Faulty clutch parts can make various noises. When an operator reports that a clutch is making noise, find out when the noise is heard. Does the sound occur when the pedal is moved, when in neutral, when in gear, or when the pedal is held to the floor? This will assist you in determining which parts are producing these noises.

An operator reports hearing a scraping, clunking, or squeaking sound when the clutch pedal is moved up or down. This is a good sign of a worn or unlubricated clutch release mechanism. With the engine off, pump the pedal and listen for the sound. Once the source of the sound is located, you should clean, lubricate, or replace the parts as required.

Sounds produced from the clutch, when the clutch is initially ENGAGED, are generally due to friction disc problems, such as a worn clutch disc facing, which causes a metal-to-metal grinding sound. A rattling or a knocking sound may be produced by weak or broken clutch disc torsion springs. These sounds indicate problems that require the removal of the transmission and clutch assembly for repair.

If clutch noises are noticeable when the clutch is DISENGAGED, the trouble is most likely the clutch release bearing. The bearing is probably either worn, binding, or, in some cases, loses its lubricant. Most clutch release bearings are factory lubricated; however, on some larger trucks and construction equipment, the bearing requires periodic lubrication. A worn pilot bearing may also produce noises when the clutch is disengaged. The worn pilot bearing can let the transmission input shaft and clutch disc vibrate up and down, causing an unusual noise.

Sounds heard in NEUTRAL, that disappear when the clutch pedal is pushed, are caused by problems inside the transmission. Many of these sounds are due to worn bearings. However, always refer to the troubleshooting chart in the manufacturer's manual.

Pedal Pulsation

A pulsating clutch pedal is caused by the runout (wobble or vibration) of one of the rotating members of the clutch assembly. A series of slight movements can be felt on the clutch pedal. These pulsations are noticeable when light foot pressure is applied. This is an indication of trouble that could result in serious damage if not corrected immediately. There are several conditions that can cause these pulsations. One possible cause is misalignment of the transmission and engine.

If the transmission and engine are not in line, detach the transmission and remove the clutch assembly. Check the clutch housing alignment with the engine and crankshaft. At the same time, the flywheel can be checked for runout, since a bent flywheel or crankshaft flange will produce clutch pedal pulsation. If the flywheel does not seat on the crankshaft flange, remove the flywheel. After cleaning the crankshaft flange and flywheel, replace the flywheel, making sure a positive seat is obtained between the flywheel and the flange. If the flange is bent, the crankshaft must be replaced.

Other causes of clutch pedal pulsation include bent or maladjusted pressure plate release levers, warped pressure plate, or warped clutch disc. If either the clutch disc or pressure plate is warped, they must be replaced.

CLUTCH OVERHAUL

When adjustment or repair of the linkage fails to remedy problems with the clutch, the clutch must be removed for inspection. Any faulty parts should be discarded and replaced with new or rebuilt components. If replacement parts are not readily available, a decision to use the old components should be based on the manufacturer's recommendations and the maintenance supervisor.

Transmission or transaxle removal is required to service the clutch. Always follow the detailed directions in the service manual. To remove the clutch in a rear-wheel drive vehicle, remove the drive shaft, the clutch fork, the clutch release mechanism, and the transmission. With a front-wheel drive vehicle, the axle shafts (drive axles), the transaxle, and, in some cases, the engine must be removed for clutch repairs.

WARNING

When the transmission or transaxle is removed, support the weight of the engine. Never let the engine, the transmission, or the transaxle be unsupported. The transmission input shaft, clutch fork, engine mounts, and other associated parts could be damaged.

After removal of the transmission or transaxle, remove the clutch housing from the rear of the engine. Support the housing as you remove the last bolt. Be careful not to drop the clutch housing as you pull it away from the dowel pins.

Using a hammer and a center punch, mark the pressure plate and flywheel. These marks are needed when reinstalling the same pressure plate to assure correct balancing of the clutch.

With the clutch removed, all components are to be cleaned and inspected for wear and damage. After cleaning, you should inspect the flywheel and pressure plate for signs of unusual wear, such as scoring or cracks. A straightedge should be used to check for war-page of the pressure plate. Using a dial indicator, measure the runout of the flywheel. The pressure plate release levers should show very limited or no signs of wear from contact with the release bearing. If excessive wear, cracks, or warpage is noted on the flywheel and/or pressure plate, the assembly should be replaced. This is also a good time to inspect the ring gear teeth on the flywheel. If they are worn or chipped, a new ring gear should be installed.

NOTE

Be careful how you clean the parts of the clutch. Avoid using compressed air to blow clutch dust from the parts. A clutch disc contains asbestos—a cancer-causing substance.

While inspecting the flywheel, you should check the pilot bearing in the end of the crankshaft. A worn pilot bearing will allow the transmission input shaft and clutch disc to wobble up and down. Using a telescoping gauge and a micrometer, measure the amount of wear in the bushing. For wear measurements of the pilot bearing, refer to the service manual. If a roller bearing is used, rotate them. They should turn freely and show no signs of rough movement. If replacement of the pilot bearing is required, the use of a slide hammer puller will drive the bearing out of the crankshaft end. Before installing a new pilot bearing, check the fit by sliding it over the input shaft of the transmission. Then drive the new bearing into the end of the crankshaft.

Inspect the disc for wear; inspect the depth of the rivet holes, loose rivets, and worn or broken torsion springs. Check the splines in the clutch disc hub for a "like new" condition. The clutch shaft splines should be inspected by placing the disc on the clutch shaft and sliding it over the splines. The disk should move relatively free back and forth without any unusual tightness or binding. Normally, the clutch disc is replaced anytime the clutch is tom down for repairs.

Another area to inspect is the release bearing. The release bearing and sleeve is usually sealed and factory packed (lubricated). A bad release bearing will produce a grinding noise whenever the clutch pedal is pushed down. To check the action of the release bearing, insert your fingers into the bearing; then turn the bearing while pushing on it. Try to detect any roughness; it should rotate smoothly. Also, inspect the spring clip on the release bearing or fork. If bent, worn, or fatigued, the bearing or fork must be replaced.

The last area to check before reassembly is the clutch fork. If it is bent or worn, the fork can prevent the clutch from releasing properly. Inspect both ends of the fork closely. Also, inspect the clutch fork pivot point in the clutch housing; the pivot ball or bracket should be undamaged and tight.

When a new pressure plate is installed, do not forget to check the plate for proper adjustments. These adjustments will ensure proper operation of the pressure plate. The first adjustment ensures proper movement of the pressure plate in relation to the cover. With the use of a straightedge and a scale as shown in figure 4-11, begin turning the adjusting screws until you obtain the proper clearance between the straight-edge and the plate as shown. For exact measurements, refer to the manufacturer's service manual.

The second adjustment positions the release levers and allows the release bearing to contact the levers simultaneously while maintaining adequate clearance of the levers and disc or pressure plate cover. This adjustment is known as finger height. To adjust the pressure plate, place the assembly on a flat surface and measure the height of the levers, as shown in figure 4-12. Adjust it by loosening the locknut and turning. After the proper height has been set, make sure the locknuts are locked and staked with a punch to keep them from coming loose during operations. Exact release lever height can be found in the manufacturer's service manual.

Reassemble the clutch in the reverse order of disassembly. Mount the clutch disc and pressure plate on the flywheel. Make sure the disc is facing in the right direction. Usually, the disc's offset center (hub and torsion springs) fit into the pressure plate.

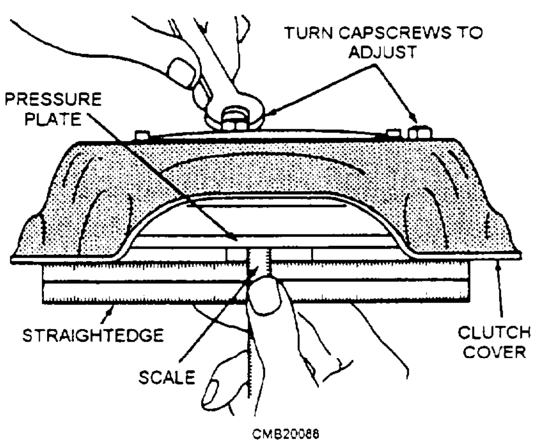

Figure 4-11.—Pressure plate adjustment.

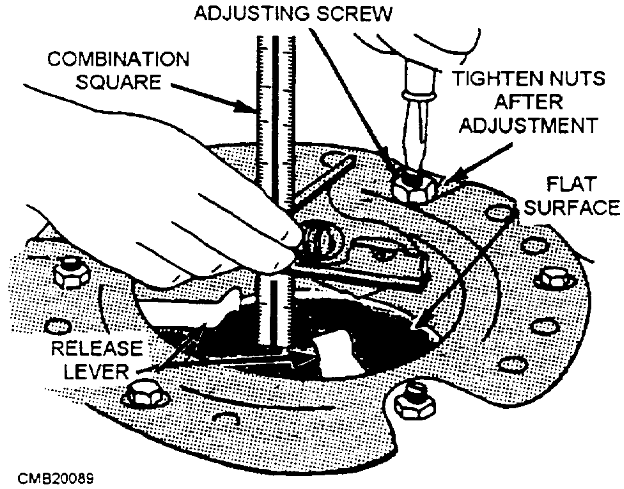

Figure 4-12.—Pressure plate release lever adjustment.

If reinstalling, the old pressure plate lines up the alignment marks made before disassembly. Start all of the pressure plates bolts by hand. Never replace a clutch pressure plate bolt with a weaker bolt. Always install the special case-hardened bolt recommended by the manufacturer.

Use a clutch alignment tool to center the clutch disc on the flywheel. If an alignment tool is unavailable, an old clutch shaft from the same type of vehicle may be used. Tighten each pressure plate bolt a little at a time in a **crisscross pattern.** This will apply equal pressure on each bolt, as the pressure plate spring(s) are compressed. When the bolts are snugly in place, torque them to the manufacturer's specifications found in the service manual. Once the pressure plates bolts are torqued to specs, slide out the alignment tool. Without the clutch disc being centered, it is almost impossible to install the transmission or transaxle.

Next install the clutch fork and release bearing in the clutch housing. Fit the clutch housing over the rear of the engine. Dowels are provided to align the housing on the engine. Install and tighten the bolts in a crisscross manner.

Install the transmission and drive shaft or the transaxle and axle shafts. Reconnect the linkages, the cables, any wiring, the battery, and any other parts required for disassembly. After all parts have been installed, adjust the clutch pedal free travel as prescribed by the manufacturer and test-drive the vehicle for proper operation.

REVIEW 1 QUESTIONS

Q1. What is the function of the automotive clutch?

Q2. What component(s) allow(s) the operator to operate the clutch?

Q3. What component(s) transfer(s) motion from the release mechanism to the release bearing and pressure plate?

Q4. What component(s) within the clutch disc absorb(s) vibration and shock produced by clutch engagement?

Q5. What component prevents the engine starting unless the clutch pedal is fully depressed?

Q6. If no service manual is available and an adjustment of the clutch is required, what amount of clutch pedal free travel will allow adequate clutch operation?

MANUAL TRANSMISSIONS

Learning Objective: State the operating principles, identify the components, and maintenance of a manual transmission.

A manual transmission is designed with two purposes in mind. One purpose of the transmission is providing the operator with the option of maneuvering the vehicle in either the forward or reverse direction. This is a basic requirement of all automotive vehicles. Almost all vehicles have multiple forward gear ratios, but, in most cases, only one ratio is provided for reverse.

Another purpose of the transmission is to provide the operator with a selection of gear ratios between engine and wheel so that the vehicle can operate at the best efficiency under a variety of operating conditions and loads. If in proper operating condition, a manual transmission should do the following:

- Be able to increase torque going to the drive wheel for quick acceleration.
- Supply different gear ratios to match different engine load conditions.
- Have a reverse gear for moving the vehicle backwards.
- Provide the operator with an easy means of shifting transmission gears.
- Operate quietly with minimum power loss.

TRANSMISSION CONSTRUCTION

Before understanding the operation and power flow through a manual transmission, you first must understand the construction of the transmission. This is necessary for you to be able to diagnose and repair damaged transmissions properly.

Transmission Case

The transmission case provides support for the bearings and shafts, as well as an enclosure for lubricating oil. A manual transmission case is cast from either iron or aluminum. Because they are lighter in weight, aluminum cases are preferred.

A drain plug and fill plug are provided for servicing. The drain plug is located on the bottom of the case, whereas the fill plug is located on the side.

Extension Housing

Also known as the tail shaft, the extension housing bolts to the rear of the transmission case. It encloses and holds the transmission output shaft and rear oil seal. A gasket is used to seal the mating surfaces between the transmission case and the extension housing. On the bottom of the extension housing is a flange that provides a base for the transmission mount.

Front Bearing Hub

Sometimes called the front bearing cap, the bearing hub covers the front transmission bearing and acts as a sleeve for the clutch release bearing. It bolts to the transmission case and a gasket fits between the front hub and the case to prevent oil leakage.

Transmission Shafts

A manual transmission has four steel shafts mounted inside the transmission case. These shafts are the input shaft, the countershaft, the reverse idler shaft, and the main shaft.

INPUT SHAFT.—The input shaft, also known as the clutch shaft, transfers rotation from the clutch disc to the countershaft gears (fig. 4-13). The outer end of the shaft is splined except the hub of the clutch disc. The inner end has a machined gear that meshes with the countershaft. A bearing in the transmission case supports the input shaft in the case. Anytime the clutch disc turns, the input shaft gear and gears on the countershaft turn.

COUNTERSHAFT.—The countershaft, also known as the *cluster gear shaft,* holds the countershaft gear into mesh with the input shaft gear and other gears in the transmission (fig. 4-14). It is located slightly below and to one side of the clutch shaft. The countershaft does not turn in the case. It is locked in place by either a steel pin, force fit, or locknuts.

REVERSE IDLER SHAFT.—The *reverse idler shaft* is a short shaft that supports the reverse idle gear (fig. 4-15). It mounts stationary in the transmission case about halfway between the countershaft and output shaft, allowing the reverse idle gear to mesh with both shafts.

MAIN SHAFT.—The main shaft, also called the *output shaft,* holds the output gears and synchronizers (fig. 4-16). The rear of the shaft extends to the rear of the extension housing where it connects to the drive shaft to turn the wheel of the vehicle. Gears on the shaft are free to rotate, but the synchronizers are locked on the shaft by splines. The synchronizers will only turn when the shaft itself turns.

Transmission Gears

Transmission gears can be classified into four groups—input gear, countershaft gears, main shaft gears, and the reverse idler gear. The input gear turns

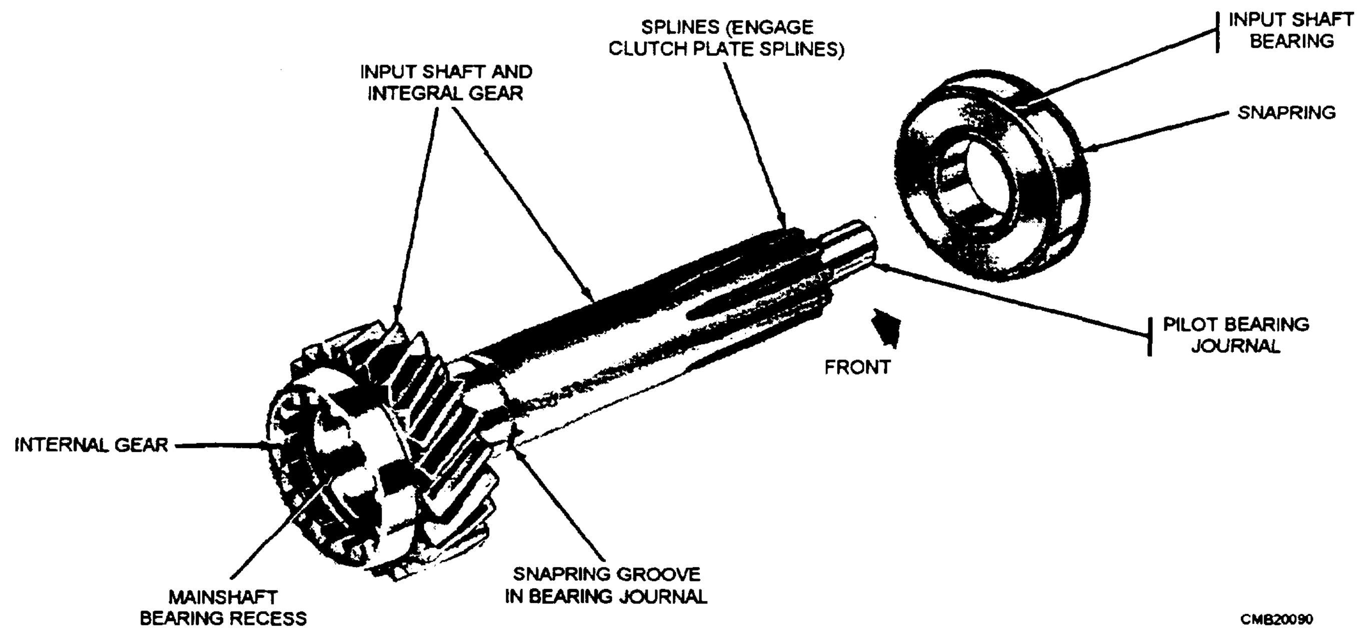

Figure 4-13.—Transmission input shaft and bearing.

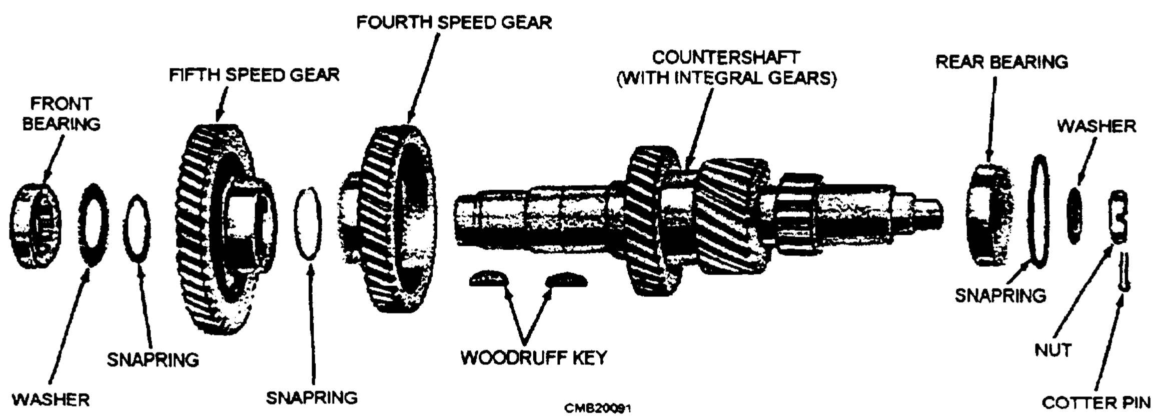

Figure 4-14.—Transmission countershaft assembly—exploded view.

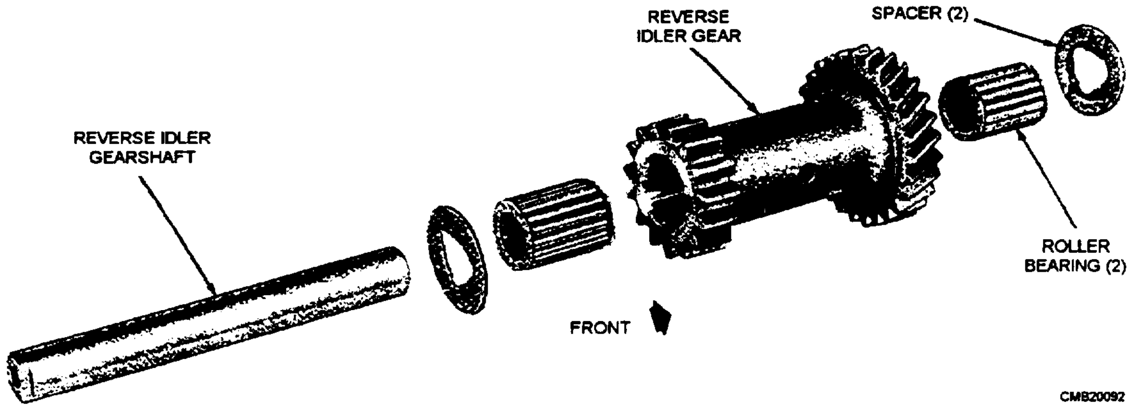

Figure 4-15.—Reverse idler shaft and gear assembly-exploded view.

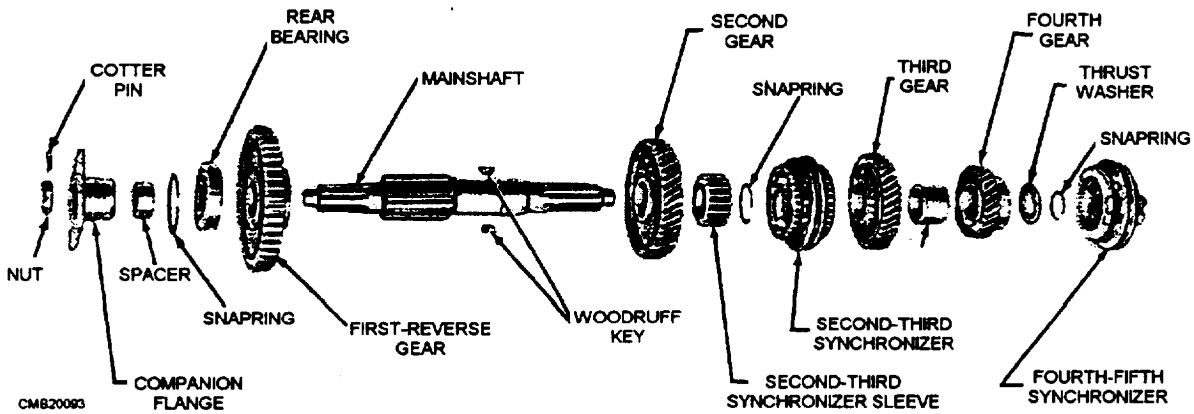

Figure 4-16.—Transmission main shaft assembly-exploded view.

the countershaft gears, the countershaft gears turns the main shaft gears, and, when engaged, the reverse idler gear.

In low gear, a small gear on the countershaft drives a larger gear on the main shaft, providing for a high gear ratio for accelerating. Then, in high gear, a larger countershaft gear turns a small main shaft gear or a gear of equal size, resulting in a low gear ratio, allowing the vehicle to move faster. When reverse is engaged, power flows from the countershaft gear, to the reverse idler gear, and to the engaged main shaft gear. This action reverses main shaft rotation.

Synchronizers

The synchronizer is a drum or sleeve that slides back and forth on the splined main shaft by means of the shifting fork. Generally, it has a bronze cone on each side that engages with a tapered mating cone on the second- and high-speed gears. A transmission synchronizer (fig. 4-17) has two functions, which are as follows:

1. Lock the main shaft gear to the main shaft.
2. Prevent the gear from clashing or grinding during shifting.

When the synchronizer is moved along the main shaft, the cones act as a clutch. Upon touching the gear that is to be engaged, the main shaft is accelerated or slowed down until the speeds of the main shaft and gear are synchronized. This action occurs during partial movement of the shift lever. Completion of lever movement then slides the sleeve and gear into complete engagement. This action can be readily understood by remembering that the hub of the sleeve slides on the splines of the main shaft to engage the cones; then the sleeve slides on the hub to engage the gears. As the synchronizer is slid against a gear, the gear is locked to the synchronizer and to the main shaft. Power can then be sent out of the transmission to the wheels.

Shift Forks

Shift forks fit around the synchronizer sleeves to transfer movement to the sleeves from the shift

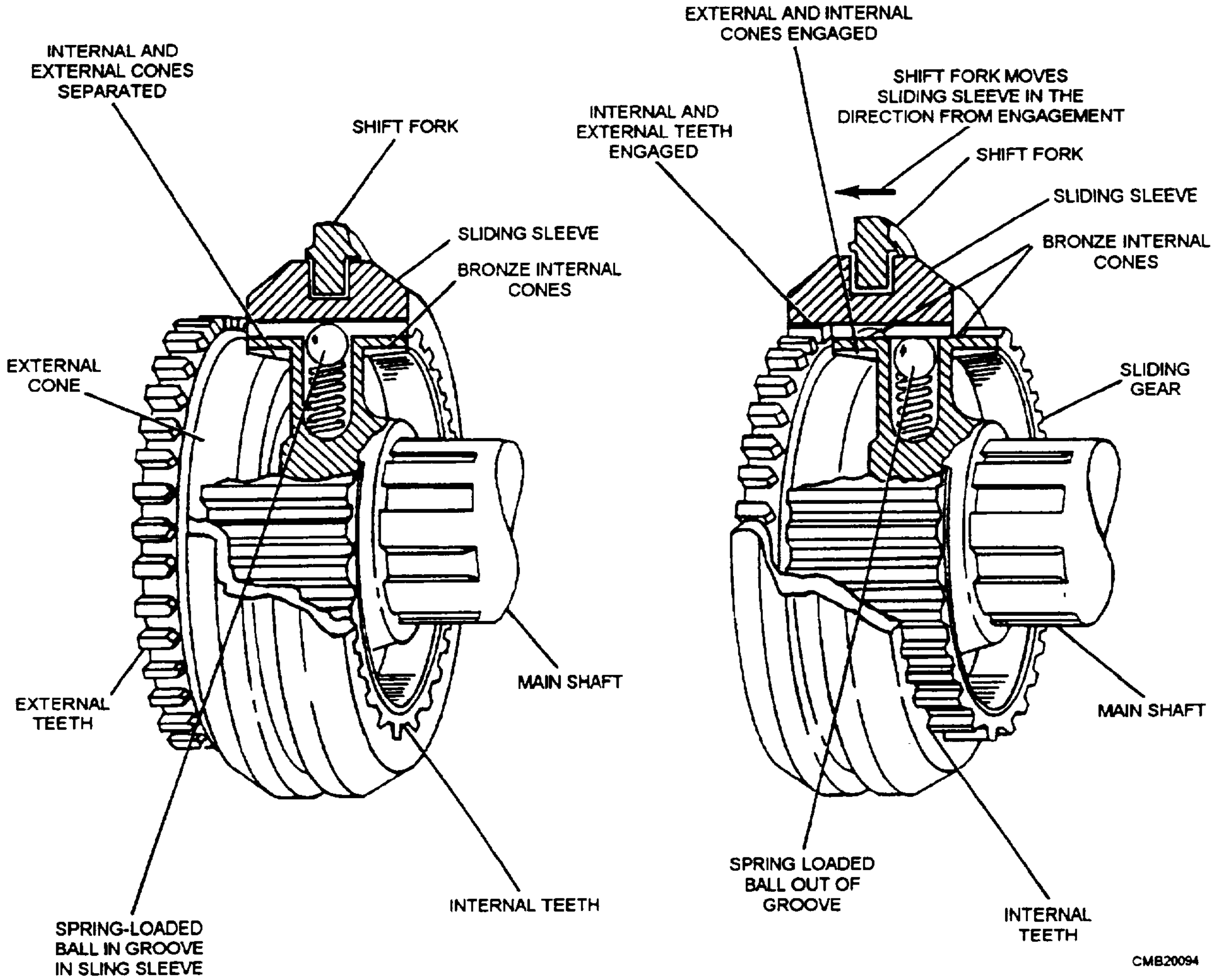

Figure 4-17.—Synchronizers.

linkage. The shift fork sets in a groove cut into the synchronizer sleeve. The linkage rod or shifting rail connects the shift fork to the operator's shift lever. As the lever moves, the linkage or rail moves the shift fork and synchronizer sleeve to engage the correct transmission gear.

Shift Linkage and Levers

There are two types of shift linkages used on manual transmissions. They are the EXTERNAL ROD and the INTERNAL SHIFT RAIL. They both perform the same function. They connect the shift lever with the shift fork mechanism.

The transmission shift lever assembly can be moved to cause movement of the shift linkage, shift forks, and synchronizers. The shift lever may be either floor mounted or column mounted, depending upon the manufacturer. Floor-mounted shift levers are generally used with an internal shift rail linkage, whereas column-mounted shift levers are generally used with an external rod linkage.

TRANSMISSION TYPES

Manual transmissions are of three major types:

1. Sliding gear
2. Constant mesh
3. Synchromesh

A quick overview of the three types is as follows:

- The sliding gear transmission has two or more shafts mounted in parallel or in line, with sliding spur gears arranged to mesh with each other and provide a change in speed or direction.

- The constant mesh transmission has parallel shafts with gears in constant mesh. Shifting is done by locking free-running gears to their shaft by using sliding collars.

- The synchromesh transmission also has gears in constant mesh. However, gears can be selected without clashing or grinding by synchronizing the speeds of the mating part before they engage.

The sliding gear transmission is generally used in farm and industrial machines; therefore, we will only look closely at the constant mesh and synchromesh transmissions.

Constant Mesh Transmission

To eliminate the noise developed by the spur-tooth gears used in the sliding gear transmission, automotive manufacturers developed the constant mesh transmission, also known as the collar shift transmission (fig. 4-18). The constant mesh transmission has parallel shafts with gears in constant mesh. In neutral,

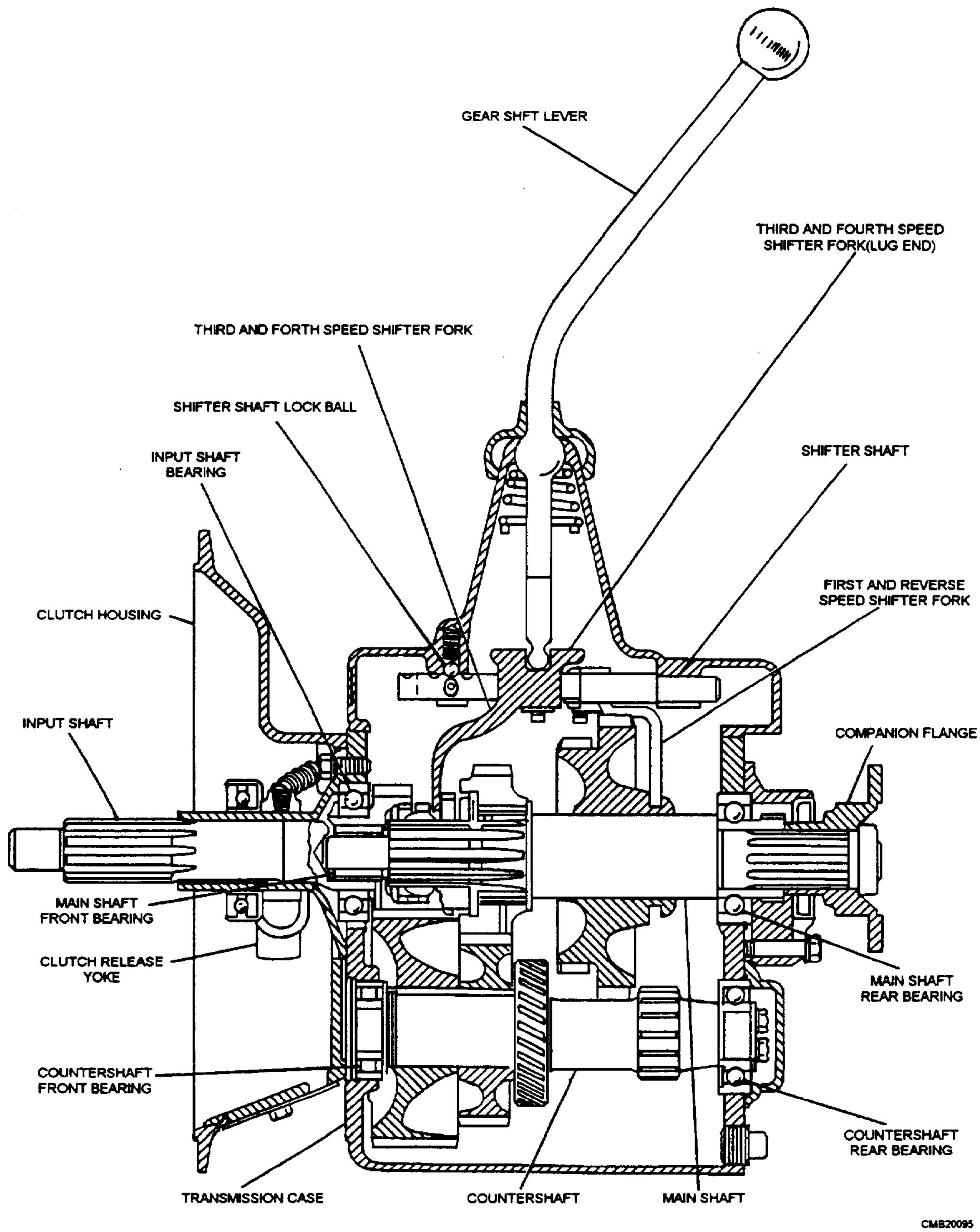

Figure 4-18.—Constant mesh transmission assembly.

the gears are free running but, when shifted, they are locked to their shafts by sliding collars.

The following is an example of the operation of a constant mesh transmission: When the shift lever is moved to THIRD, the THIRD and FOURTH shifter fork moves the sliding collar toward the THIRD speed gear. This engages the external teeth of the sliding collar with the internal teeth of the THIRD speed gear. Since the THIRD speed gear is meshed and rotating with the countershaft, the sliding collar must also rotate. The sliding collar is splined to the main shaft, and therefore, the main shaft rotates with the sliding collar. This principle is carried out when the shift lever moves from one speed to the next.

Constant mesh gears are seldom used for all speeds. Common practice is to use such gears for the higher gears, with sliding gears for FIRST and REVERSE, or for REVERSE only.

Synchromesh Transmission

The construction of the synchromesh transmission is the same as that of the constant mesh transmission with the exception that a synchronizer has been added (fig. 4-19). The addition of synchronizers allows the gears to be constant mesh when the cluster gears and the synchronizing clutch mechanisms lock the gears together.

The synchronizer accelerates or slows down the rotation of the shaft and gear, until both are rotating at the same speed and can be locked together without a gear clash. Since the vehicle is normally standing still when it is shifted into reverse gear, a synchronizer is not ordinarily used on the reverse gear.

POWER FLOW

Now that you understand the basic parts and construction of a manual transmission, we will cover the flow of power through a five-speed synchromesh transmission. In this example neither first gear nor reverse gear are synchronized.

Reverse Gear

In passing from neutral to reverse, the first-reverse main shaft gear is shifted rearward to mesh with the reverse idler gear (fig. 4-20, view A). The sole function of this gear is to make the main shaft rotate in the opposite direction to the input shaft; it does not affect gear ratio.

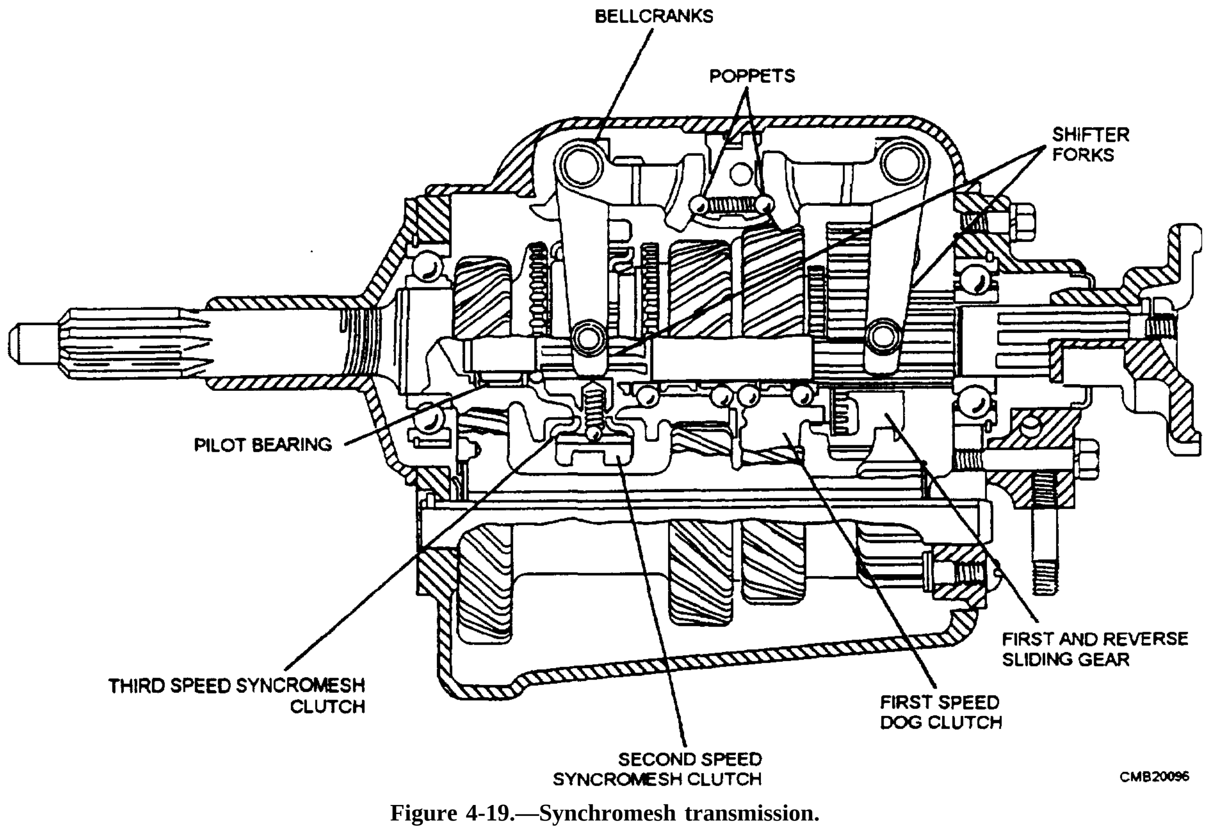

Figure 4-19.—Synchromesh transmission.

First Gear

To get the vehicle moving from a standstill, the operator moves the gearshift lever into first. The main shaft first-reverse speed gear is slid into position, meshing the gear with the countershaft first-speed gear. The countershaft first-speed gear and main shaft first-reverse speed gear transmits power to the main shaft (fig. 4-20, view B). Gear ratio is approximately 7.55 to 1.

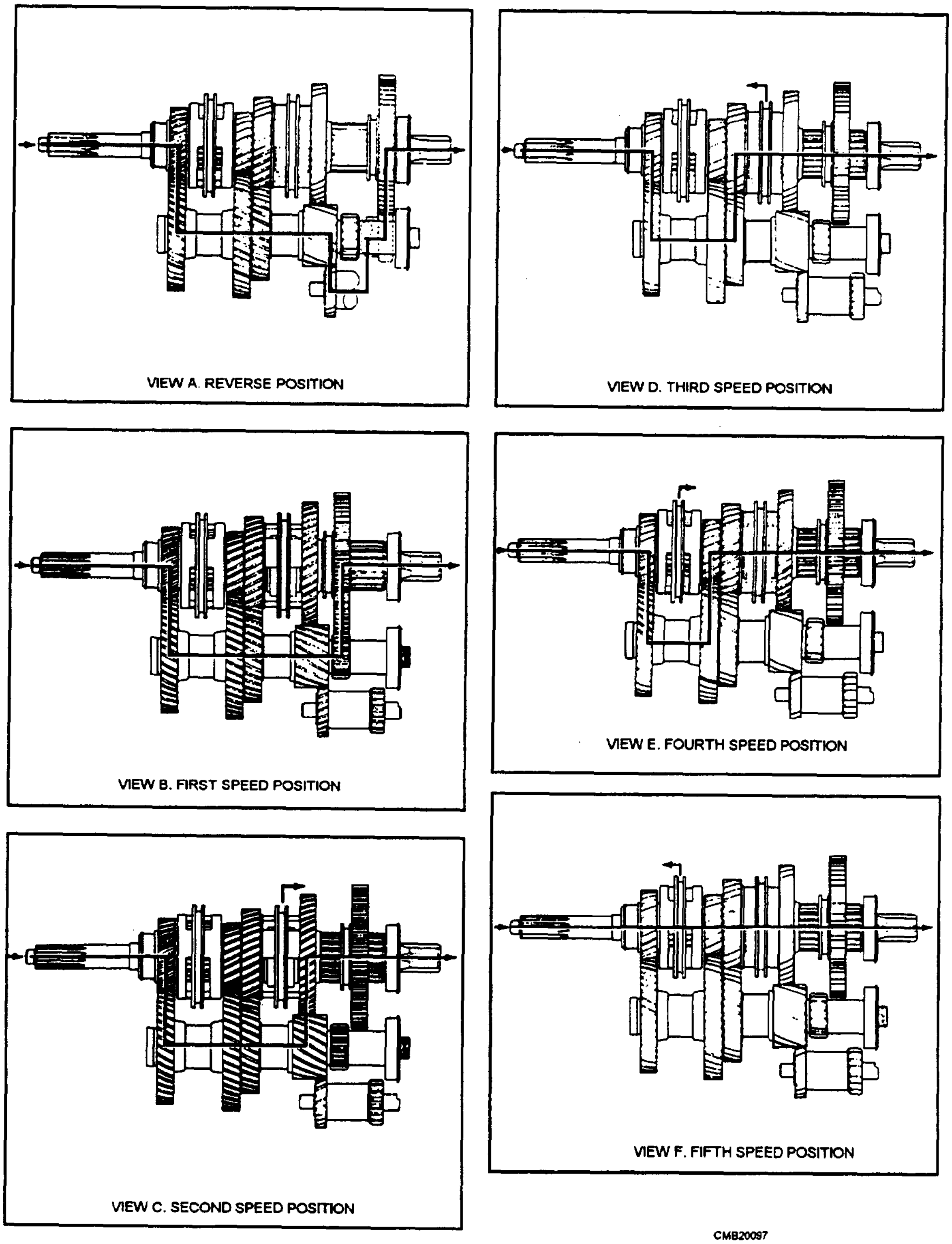

Figure 4-20.—Power flow of a five-speed transmission.

Second Gear

To shift into second, the operator depresses the clutch and moves the shift lever into second gear. The second-third-speed synchronizer has been moved to the right so its internal teeth engage the external teeth of the main shaft second-speed gear. Power is transmitted by the countershaft second-speed gear to the main shaft second-speed gear, which is coupled to the main shaft by the second-third-gear synchronizer, and to the main shaft (fig. 4-20, view C). Gear ratio is approximately 4.18 to 1.

Third Gear

To shift into third, the operator depresses the clutch and moves the shift lever disengaging the second-third synchronizer from the main shaft second-speed gear. The second-third-speed synchronizer has been moved to the left so its internal teeth engage the external teeth of the main shaft third-speed gear. Power is transmitted by the countershaft third-speed gear to the main shaft third-speed gear, which is coupled to the main shaft by the second-third synchronizer and through the main shaft (fig. 4-20, view D). Gear ratio is approximately 2.45 to 1.

Fourth Gear

The operator depresses the clutch and moves the shift lever disengaging the second-third synchronizer from the main shaft third-speed gear. The fourth-fifth-speed synchronizer has been moved to the right so its internal teeth engage the external teeth of the main shaft fourth-speed gear. Power is transmitted by the countershaft fourth-speed gear through the main shaft fourth-speed gear, which is coupled to the main shaft by the fourth-fifth-speed synchronizer, and through the main shaft (fig. 4-20, view E). Gear ratio is approximately 1.45 to 1.

Fifth Gear

The operator depresses the clutch and moves the shift lever disengaging the fourth-fifth-speed synchronizer from the main shaft fourth-speed gear. The fourth-fifth-speed synchronizer is moved to the left so its internal teeth engage the external teeth of the input gear. Power is transmitted by the input gear, which is coupled to the main shaft by the fourth-fifth-speed synchronizer. Since the interlocking action of the synchronizer, in effect, makes one continuous shaft of the input shaft and the main shaft, the drive is direct (fig. 4-20, view F). Gear ratio is 1.00 to 1.

AUXILIARY TRANSMISSIONS

The auxiliary transmission (fig. 4-21) is used to provide additional gear ratios in the power train. This transmission is installed behind the main transmission and power flows directly to it from the main transmission, when of the integral type, or by a short propeller shaft (jack shaft) and universal joints.

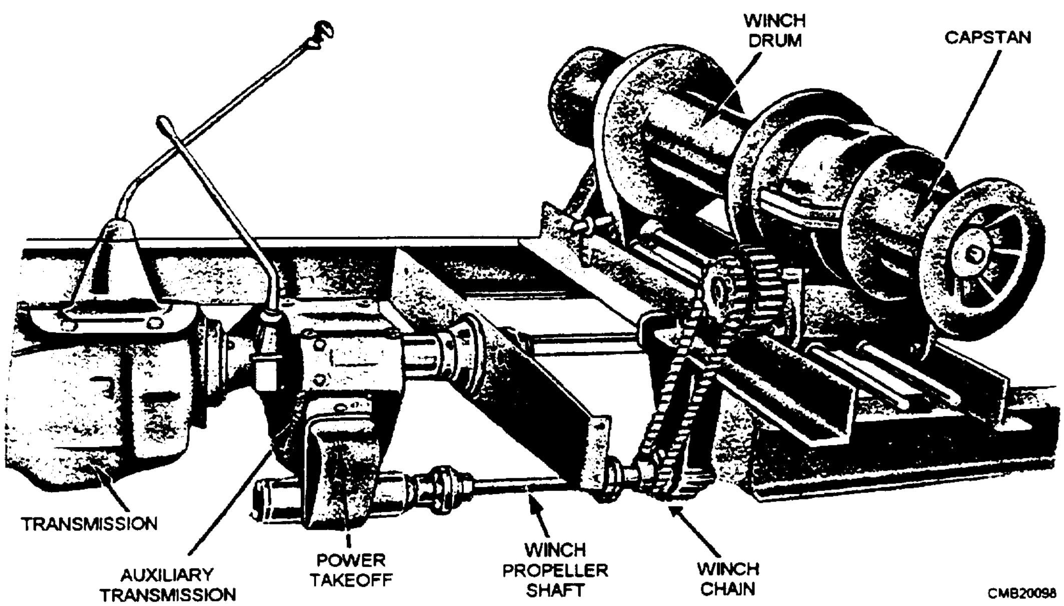

Figure 4-21.—Auxiliary transmission with power takeoff used for driving winch.

Support and alignment are provided by a frame cross member. Rubber-mounting brackets are used to isolate vibration and noise from the chassis. A lever that extends into the operator's compartment accomplishes shifting. Like the main transmission, the auxiliary transmission may have either constant mesh gears or synchronizers to allow for easier shifting.

This transmission, when of the two-speed design, has a low range and direct drive. Three- and four-speed auxiliary transmissions commonly have at least one overdrive gear ratio. The OVERDRIVE position causes increased speed of the output shaft in relation to the input shaft. Overdrive is common on heavy-duty trucks used to carry heavy loads and travel at highway speeds.

The auxiliary transmission shown in figure 4-22 provides two-speed ratios. When it is in the DIRECT DRIVE position, power flows directly through the transmission and is controlled only by the main transmission. When the auxiliary transmission is shifted into LOW RANGE, vehicle speed is reduced and torque is increased. When the low range is used with the lowest speed of the main transmission, the engine drives the wheels very slowly and with less engine horsepower.

In this constant mesh auxiliary transmission, the main gear is part of the input shaft, and it is in constant mesh with the countershaft drive gear. A pilot bearing aligns the main shaft output shaft with the input shaft. The low-speed main shaft gear runs free on the main shaft when direct drive is being used and is in constant mesh with the countershaft low-speed gear. A gear-type dog clutch, splined to the main shaft, slides forward or backward when you shaft the auxiliary transmission into high or low gear position.

In HIGH GEAR, when direct drive from the main transmission is being used, the dog clutch is forward and makes a direct connection between the input shaft and the main shaft. When in LOW GEAR, the dog clutch is meshed with the low-speed, main shaft gear and is disengaged from the main drive gear.

TRANSMISSION TROUBLESHOOTING

Transmissions are designed to last for the life of the vehicle when lubricated and operated properly. The most common cause of failure results from shifting when the vehicle is not completely stopped or without waiting long enough to allow the gears to stop spinning after depressing the clutch pedal. This slight clashing

Figure 4-22.—Sectional view of an auxiliary transmission showing gear arrangement.

of gears may not seem significant at the time, but each time this occurs, small particles of the gears will be ground off and carried with the lubricate through the transmission. These small metal particles may become embedded in the soft metal used in synchronizers, reducing the frictional quality of the clutch. At the same time, these particles damage the bearings and their races by causing pitting, rough movement, and noise. Soon transmission failure will result. When this happens, you will have to remove the transmission and replace either damaged parts or the transmission unit.

As a mechanic, the first step toward repairing a transmission is the diagnosis of the problem. To begin diagnosis, gather as much information as possible. Determine in which gears the transmission acts up—first, second, third, fourth, or in all forward gears when shifting. Does it happen at specific speeds? This information will assist you in determining which parts are faulty. Refer to a diagnosis chart in the manufacturer's service manual when a problem is difficult to locate. It will be written for the exact type of transmission.

TROUBLESHOOTING A MANUAL TRANSMISSION

Problem	**Possible Cause**	**Corrective Actions**
Transmission noise in neutral	Transmission not aligned with engine	Realign
	Bearings dry, badly worn, or broken	Lubricate or replace
	Low oil level	Refill
	Gears worn, scuffed, or broken	Replace
	Countershaft badly worn	Replace
	Excessive end play of countershaft	Replace
Transmission noisy in gear	All causes noted above	Same as above
	Main shaft rear bearing worn or broken	Replace
	Gear teeth worn	Replace
	Engine vibration damper defective	Replace
	Speedometer drive gears worn	Replace
	Clutch disc defective	Replace
	Gears loose on main shaft	Replace worn parts
Hard to shift	Clutch not releasing	Adjust
	Sliding gear tight on shaft splines	Clean splines or replace shaft or gear
	Shift linkage out of adjustment	Adjust
	Main shaft splines distorted	Clean or replace
	Synchronizer damaged	Replace
	Sliding gear teeth damaged	Replace
Gears clash or grind when shifting	Clutch not releasing	Adjust
	Synchronizer defective	Replace
	Gears sticking on main shaft	Free up gears or replace defective parts
Transmission sticks in gear	Clutch not releasing	Adjust
	Detent balls stuck.	Free up the balls
	Shift linkage out of adjustment	Adjust

TROUBLESHOOTING A MANUAL TRANSMISSION—CONTINUED		
Problem	**Possible Cause**	**Corrective Action**
Transmission sticks in gear—Continued	Sliding gears tight on shaft splines	Clean splines or replace shaft or gears
Slips out of gear	Shift linkage out of adjustment	Adjust
	Gear loose on shaft	Replace shaft or gear
	Gear teeth worn	Replace
	Excessive end play in gears	Replace
	Lack of spring tension on shift lever detent	Install new spring
	Badly worn transmission bearings	Replace
Transmission leaks oil	Oil level too high	Drain to proper level
	Damaged gaskets	Install new gaskets
	Oil seal damaged or installed improperly	Install new seals
	Oil throw rings damaged, improperly installed, or missing	Install new oil throw rings properly

Many problems that seem to be caused by the transmission are caused by clutch, linkage, or drive line problems. Keep this in mind before removing and disassembling a transmission.

TRANSMISSION OVERHAUL

Because of the variations in construction of transmissions, always refer to the manufacturer's service manual for proper procedures in the removal, disassembly, repair, assembly, and installation. These operations vary from 6 to 8 hours, depending on transmission type and vehicle manufacturer.

The basic removal procedures are as follows:

1. Unscrew the transmission drain plug and drain the oil.
2. Remove the drive shaft and install a plastic cap over the end of the transmission shaft.
3. Disconnect the transmission linkage at the transmission.
4. Unbolt and remove the speedometer cable from the extension housing.
5. Remove all electrical wires leading to switches on the transmission.
6. Remove any cross members or supports.
7. Support the transmission and engine with jacks. Operate the jack on the engine to take the weight off the transmission. Be careful not to crush the oil pan.

CAUTION

Never let the engine hang suspended by only the front motor mounts.

8. Depending upon what is recommended by the service manual, either remove the transmission-to-clutch cover bolts or the bolts going into the engine from the clutch cover.
9. Slide the transmission straight back, holding it in alignment with the engine. You may have to wiggle the transmission slightly to free it from the engine.

Once the transmission has been removed from the engine, clean the outside and place it on your workbench. Teardown procedures will vary from one transmission to another. Always consult the service manual for the type of transmission you are working on. If improper disassembly methods are used, major part damage could possibly result.

Before disassembly, remove the inspection cover. This will allow you to observe transmission action. Shift the transmission into each gear, and, at the same time, rotate the input shaft while inspecting the conditions of the gears and synchronizers.

The basic disassembly procedures are as follows:

1. Unbolt and remove the rear extension housing. It may be necessary to tap the housing off with a soft face mallet or bronze hammer.

2. Unbolt and remove the front extension housing and any snap rings.

3. Carefully pry the input shaft and gear forward far enough to free the main shaft.

4. Using a brass driftpin, push the reverse idler shaft and countershaft out of the transmission case.

5. Remove the input shaft and output shaft assemblies. Slide the output shaft and gears out of the back of the transmission as a unit. Be careful not to damage any of the gears.

After the transmission is disassembled, clean all the parts thoroughly and individually. Clean all the parts of hardened oil, lacquer deposits, and dirt. Pay particular attention to the small holes in the gears and to the shifter ball bores in the shifter shaft housing. Remove all gasket material using a putty knife or other suitable tool. Ensure that the metal surfaces are not gouged or scratched. Also, clean the transmission bearings and blow-dry them using low-pressure compressed air.

NOTE

Always use protective eyewear when you are blowing the bearing dry with compressed air. Do NOT allow the bearing to spin. Air pressure can make the bearing spin at tremendously high rpm, possibly causing the bearing to explode and fly apart.

After all parts of the transmission have been cleaned, inspect everything closely to determine whether they can be reused or have to be replaced. The wear or damage to some of the parts will be evident to the eye. If brass-colored particles are found, one or more of the synchronizers or thrust washers are damaged. These are normally the only transmission parts made of this material. If iron chips are found, main drive gears are probably damaged. To check for damage or wear on other parts, it may be necessary to use measuring tools and gauges to determine their condition.

Any worn or damaged parts in the transmission must be replaced. This is why your inspection is very critical. If any trouble is NOT corrected, the transmission overhaul may fail. You would have to complete the job a second time, wasting man-hours and materials, as well as unnecessary equipment downtime.

Always replace all gaskets and seals in the transmission. Even though the seal or gasket may have not been leaking before disassembly, it may start to leak after assembly.

When replacing a main shaft gear either due to wear or damage, you should also replace the matching gear on the countershaft. If a new gear is meshed with an old gear, transmission gear noise will occur.

If new bolts are needed, make sure it is the correct thread type and length. Some transmission use metric bolts. Remember mixing threads will cause part damage.

All parts must be lightly coated with a medium-grade lubricating oil. This is done immediately after the inspection or repair. Oiling the parts give them a necessary rust-preventive coating and facilitates the assembly process.

After obtaining new parts to replace the worn or damaged parts, you are ready for transmission assembly. To assemble the transmission, use the reverse order of disassembly. Again refer to the service manual for exact directions, as well as proper clearances and wear limits of the parts. The service manual will have an exploded view of the transmission. It will show how each part is located in relation to the others. Step-by-step direction will accompany the illustrations.

Certain key areas of the transmission should be given extra attention during assembly. One area is the needle bearings. To hold the needle bearings into the countershaft or other shafts, you coat the bearings with HEAVY GREASE. The grease will hold the bearing in place as you slide the countershaft into the gears. Also, measure the end play or clearance of the gears and synchronizers and the countershaft and case as directed by the service manual.

Before installing, ensure the transmission shifts properly. This will save you from having to remove the transmission if there is still problems. Also, since the transmission is already out, this is an ideal time to inspect the condition of the clutch.

Before installation, place a small amount of grease in the pilot bearing and on the release bearing inner surface. Now, the transmission is ready to be installed. Basic transmission installation is as follows:

NOTE

DO NOT place any lubricant on the end of the clutch shaft input splines or pressure plate release levers. Grease in these locations can spray onto the clutch disc, causing clutch slippage and failure.

1. Place the transmission on the transmissionjack.
2. Position the transmission behind the engine. Ensure that the release bearing is in place on the clutch fork.
3. Carefully align the transmission and engine, ensuring that the input and output shaft lines up perfectly with the center line of the engine crankshaft. If the transmission is slightly tilted, it will not fit into place.
4. With the transmission in high gear, slowly push the transmission into the clutch housing. You may need to raise or lower the transmission slightly to keep it aligned.
5. When the transmission is almost in place, wiggle the extension housing in a circular motion while pushing toward the engine. This will help start the input shaft in the pilot bearing. The transmission will then slide into position.
6. With the transmission bolted to the clutch cover, install the rear support or cross member and transmission mount. Reinstall the clutch linkage, the transmission linkage, and any other parts.
7. Adjust the clutch.

With the transmission installed and the clutch adjusted, test-drive the vehicle for proper operation. If the transmission is noisy, extremely loose, or binds, it must be removed and disassembled for further inspection and corrective action.

TRANSMISSION SERVICE

The manual transmission should have the oil level checked at each PM. Recurrent low oil level indicates that there is leakage around the oil seals.

If you notice foaming in the oil, drain the transmission and refill it with clean oil. Foaming is evidence that water or some other lubricant that will not mix with the recommended transmission oil is present.

When it becomes necessary to change the transmission oil, the following procedure should be used:

1. Before you drain the oil, clean around the drain and fill plugs thoroughly. Both drain and fill plugs should be removed to allow the oil to drain.
2. Drain the transmission immediately after the vehicle has been operated. The oil will then be warm and will readily drain, taking along the suspended contaminants as it drains.
3. Check the drained oil for any uncommon foreign matter, such as large metal particles (steel or brass). This is a good sign of internal damage to the gears, bearings, or synchronizers. If large particles are found, notify your shop supervisor for further instructions.
4. Once the transmission has drained completely and no large metal particles are found, you replace the drain plug and refill the transmission with the proper grade of oil until it reaches the bottom of the fill plug. You then replace the till plug.

Other than the periodic check required on the transmission fluid, drain and refill are performed as prescribed by the manufacturer. You should check the bolts for tightness and inspect the case for damage each scheduled PM.

REVIEW 2 QUESTIONS

Q1. *What material is most commonly used in casting a transmission case?*

Q2. *What four shafts are located in a manual transmission?*

Q3. *What are the two functions of the synchronizer?*

Q4. *What are the two types of shift linkages used on manual transmissions?*

Q5. *What type of equipment uses a sliding gear transmission?*

Q6. *If first gear ratio is 7.55 to 1, what is the gear ratio when the transmission is shifted into reverse?*

AUTOMATIC TRANSMISSIONS

Learning Objective: State the operating principles, identify the components, and maintenance procedures of an automatic transmission.

The automatic transmission (fig. 4-23), like the manual transmission, is designed to match the load requirements of the vehicle to the power and speed range of the engine. The automatic transmission, however, does this automatically depending on throttle position, vehicle speed, and the position of the control lever. Automatic transmissions are built in models that have two-, three-, or four-forward speeds and in some that are equipped with overdrive. Operator control is limited to the selection of the gear range by moving a control lever.

The automatic transmission is coupled to the engine through a torque converter. The torque converter is used with an automatic transmission, because it does not have to be manually disengaged by the operator each time the vehicle is stopped. Because the automatic transmission shifts without any interruption of engine torque application, the cushioning effect of the fluid coupling within the torque converter is desirable.

Because the automatic transmission shifts gear ratios independent of the operator, it must do so without the operator releasing the throttle. The automatic transmission does this by using planetary gearsets whose elements are locked and released in various combinations that produce the required forward and reverse gear ratios. The locking of the planetary gearset elements is done through the use of hydraulically actuated multiple-disc clutches and brake bands. The valve body controls the hydraulic pressure that actuates these locking devices. The valve body can be thought of as a hydraulic computer that receives signals that indicate vehicle speed, throttle position, and gearset lever position. Based on this information, the valve body sends hydraulic pressure to the correct locking devices.

The parts of the automatic transmission are as follows:

- Torque converter—fluid coupling that connects and disconnects the engine and transmission.

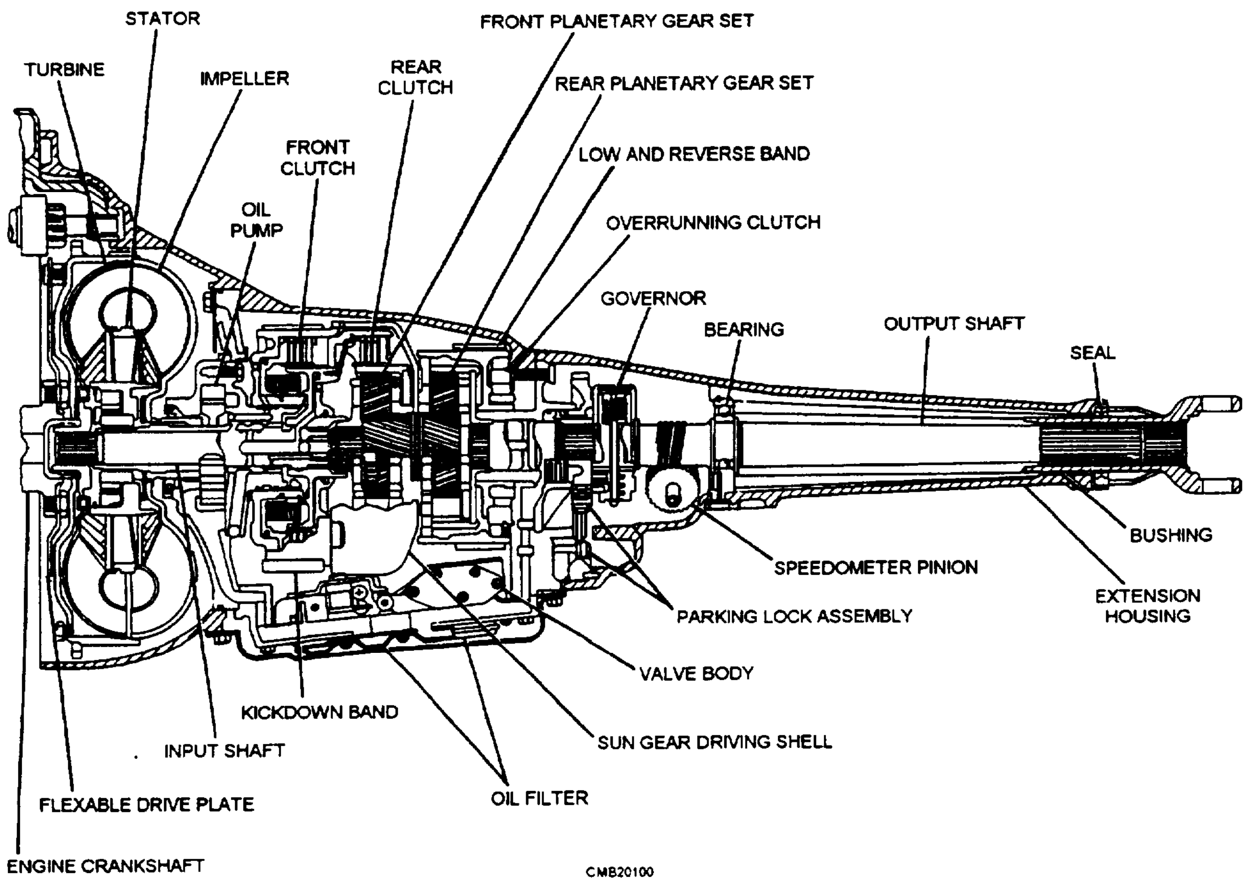

Figure 4-23.—Automatic transmission cross-sectional view.

- Input shaft—transfers power from the torque converter to internal drive members and gearsets.
- Oil pump—produces pressure to operate hydraulic components in the transmission.
- Valve body—operated by shift lever and sensors; controls oil flow to pistons and servos.
- Pistons and servos—actuates the bands and clutches.
- Bands and clutches—applies clamping or driving pressure on different parts of gearsets to operate them.
- Planetary gears—provides different gear ratios and reverse gear.
- Output shaft—transfers engine torque from the gearsets to the drive shaft and rear wheels.

TORQUE CONVERTERS

The torque converter is a fluid clutch that performs the same basic function as a manual transmission dry friction clutch (fig. 4-24). It provides a means of uncoupling the engine for stopping the vehicle in gear. It also provides a means of coupling the engine for acceleration.

A torque converter has four basic parts:

1. Outer housing—normally made of two pieces of steel welded together in a doughnut shape, housing the impeller, stator, and turbine. The housing is filled with transmission fluid.
2. Impeller—driving member that produces oil movement inside the converter whenever the engine is running. The impeller is also called the converter pump.
3. Turbine—a driven fan splined to the input shaft of the automatic transmission. Placed in front of

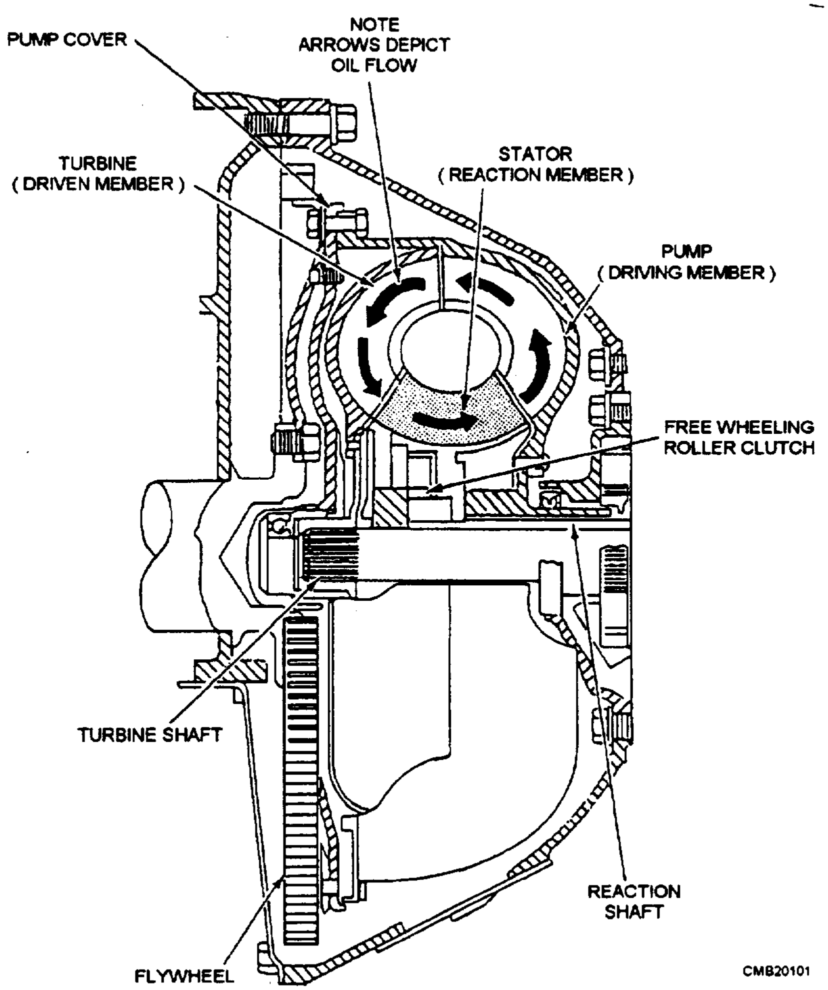

Figure 4-24.—Torque converter, partial cutaway view.

the stator and impeller in the housing. The turbine is not fastened to the impeller but is free to turn independently. Oil is the only connection between the two.

4. Stator—designed to improve oil circulation inside the torque converter. Increases efficiency and torque by causing the oil to swirl around the inside of the housing.

The primary action of the torque converter results from the action of the impeller passing oil at an angle into the blades of the turbine. The oil pushes against the faces of the turbine vanes, causing the turbine to rotate in the same direction as the impeller (fig. 4-25). With the engine idling, the impeller spins slowly. Only a small amount of oil is thrown into the stator and turbine. Not enough force is developed inside the torque converter to spin the turbine. The vehicle remains stationary with the transmission in gear.

During acceleration, the engine crankshaft, the converter housing, and the impeller begin to move faster. More oil is thrown out by centrifugal force, turning the turbine. As a result, the transmission input shaft and vehicle starts to move, but with some slippage.

At cruising speeds, the impeller and turbine spin at almost the same speed with very little slippage. When the impeller is spun fast enough, centrifugal force throws oil out hard enough to almost lock the impeller and turbine. After the oil has imparted its force to the turbine, the oil follows the contour of the turbine shell and blades so that it leaves the center section of the turbine spinning counterclockwise.

Because the turbine has absorbed the force required to reverse the direction of the clockwise spinning of the oil, it now has greater force than is being delivered by the engine. The process of multiplying engine torque has begun,

Torque multiplication refers to the ability of a torque converter to increase the amount of engine torque applied to the transmission input shaft. Torque multiplication occurs when the impeller is spinning faster than the turbine (fig. 4-26). For example, if the engine is accelerated quickly, the engine and impeller rpm might increase rapidly while the turbine is almost stationary. This is known as stall speed. Stall speed of a torque converter occurs when the impeller is at maximum speed without rotation of the turbine. This condition causes the transmission fluid to be thrown

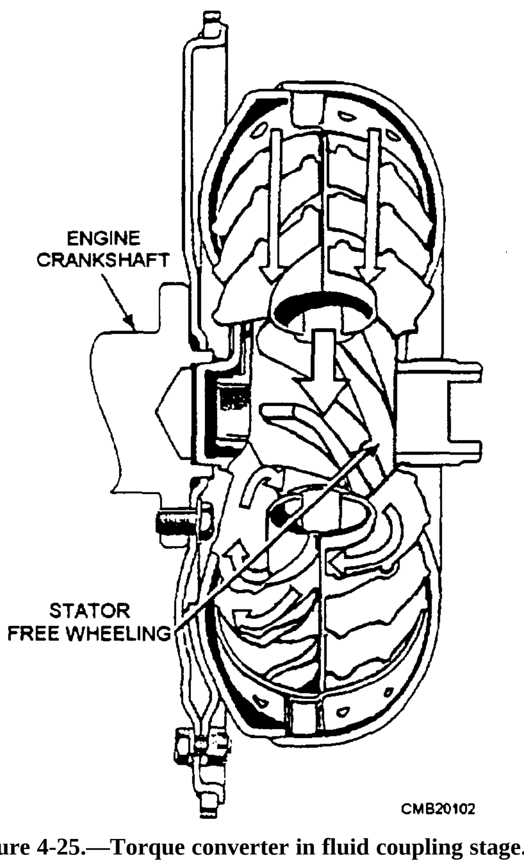

Figure 4-25.—Torque converter in fluid coupling stage.

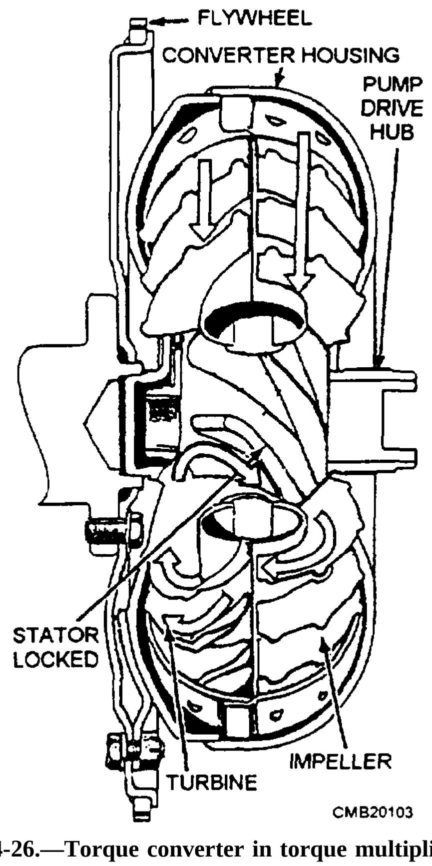

Figure 4-26.—Torque converter in torque multiplication

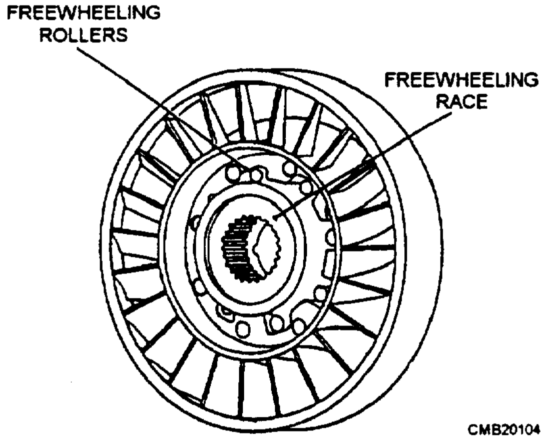

Figure 4-27.—Stator assembly.

off the stator vanes at tremendous speeds. The greatest torque multiplication occurs at stall speed.

When the turbine speed nears impeller speed, torque multiplication drops off. Torque is increased in the converter by sacrificing motion. The turbine spins slower than the impeller during torque multiplication.

If the counterclockwise oil were allowed to continue to the center section of the impeller, the oil would strike the blades of the pump in a direction that would hinder its rotation and cancel any gains in torque. To prevent this, you can add a stator assembly.

The stator (fig. 4-27) is located between the pump and the turbine and is mounted on a one-way clutch that allows it to rotate clockwise but not counterclockwise. The purpose of the stator is to redirect the oil returning from the turbine and change its rotation back to that of the impeller. Stator action is only needed when the impeller and turbine are turning at different speeds. The one-way clutch locks the stator when the impeller is turning faster than the turbine. This causes the stator to route oil flow over the impeller vanes properly. Then, when turbine speed almost equals impeller speed, the stator can freewheel on its shaft so not to obstruct flow.

Even at normal highway speeds, there is a certain amount of slippage in the torque converter. Another type of torque converter that is common on modern vehicles is the lockup torque converter (fig. 4-28). The lockup torque converter provides increased fuel economy and increased transmission life through the elimination of heat caused by torque converter slippage. A typical lockup mechanism consists of a hydraulic piston, torsion springs, and clutch friction material.

In lower gears, the converter clutch is released. The torque converter operates normally, allowing slippage and torque multiplication. However, when shifted into high or direct drive, transmission fluid is channeled to the converter piston. The converter piston pushes the friction discs together, locking the turbine and impeller. The crankshaft is able to drive the transmission input shaft directly, without slippage. The torsion springs assist to dampen engine power pulses entering the drive train.

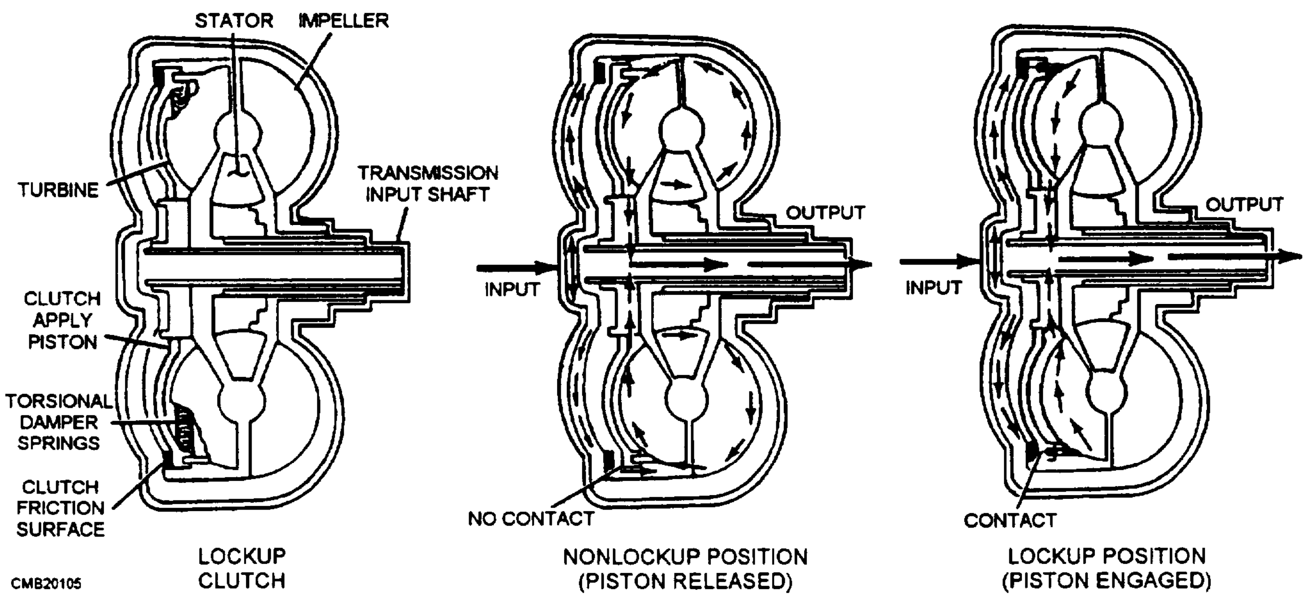

Figure 4-28.—Torque converter with lockup clutch.

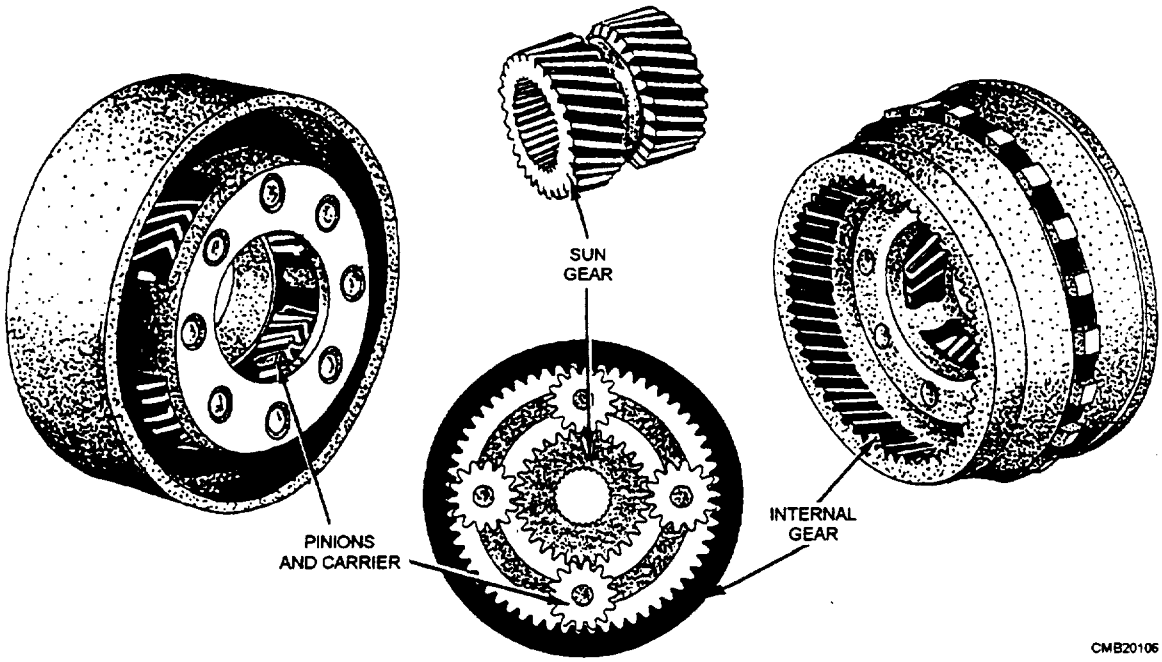

Figure 4-29.—Planetary gearset.

PLANETARY GEARSETS

A planetary gearset (fig. 4-29) consists of three members-sun gear, ring gear, and planetary carrier which holds the planetary gears in proper relation with the sun and ring gear. The planetary gears are free to rotate on their own axis while they "walk" around the sun gear or inside the ring gear.

By holding or releasing the components of a planetary gearset, it is possible to do the following:

- Reduce output speed and increase torque (gear reduction).
- Increase output speed while reducing torque (overdrive).
- Reverse output direction (reverse gear).
- Serve as a solid unit to transfer power (one to one ratio).
- Freewheel to stop power flow (park or neutral).

Figure 4-30 shows the simplest application of planetary gears in a transmission. With the application shown, two forward speeds and neutral are possible. High gear or direct drive is shown. The clutch is holding the planet carrier to the input shaft, causing the carrier and sun gear to rotate as a single unit. With the clutch released, all gears are free to rotate and no power is transmitted to the output shaft. In neutral, the planetary carrier remains stationary while the pinion gears rotate on their axis and turn the ring gear. Should the brake be engaged on the ring gear, the sun gear causes the planetary gears to walk around the inside of the ring gear and force the planet carrier to rotate in the same direction as the sun gear, but at a slower speed (low gear). To provide additional speed ranges or a reverse, you must add other planetary gearsets to this transmission.

A compound planetary gearset combines two planetary units into one housing or ring gear. It may have two sun gears or a long sun gear to operate two

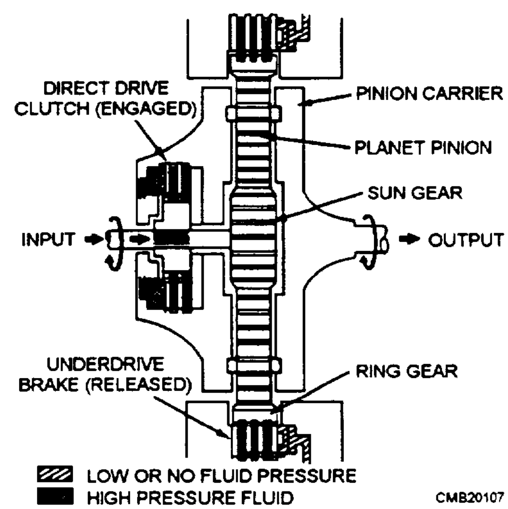

Figure 4-30.—Simple planetary gear application.

sets of planetary gears. A compound planetary gearset is used to provide more forward gear ratios than a simple planetary gearset.

CLUTCHES AND BANDS

Automatic transmission clutches and bands are friction devices that drive or lock planetary gearsets members. They are used to cause the gearset to transfer power.

Multiple-Disc Clutch

The **multiple-disc clutch** is used to transmit torque by locking elements of the planetary gearsets to rotating members within the transmission. In some cases, the multiple-disc clutch is also used to lock a planetary gearset element to the transmission case so it can act as a reactionary member. The multiple-disc clutch is made up of the following components (fig. 4-31).

DISCS AND PLATES.—The active components of the multiple-disc clutch are the discs and the plates. The discs are made of steel and are faced with a friction material. They have teeth cut into their inner circumference to key them positively to the clutch hub. The plates are made of steel with no lining. They have teeth cut into their outer circumference to key them positively with the inside of a clutch drum or to the inside of the transmission case. By alternately stacking the discs and plates, they are locked together or released by simply squeezing them.

CLUTCH DRUM AND HUB.—The clutch drum holds the stack of discs and plates and is attached to the planetary gearset element that is being driven. The clutch hub attaches to the driving member and fits inside the clutch discs and plates.

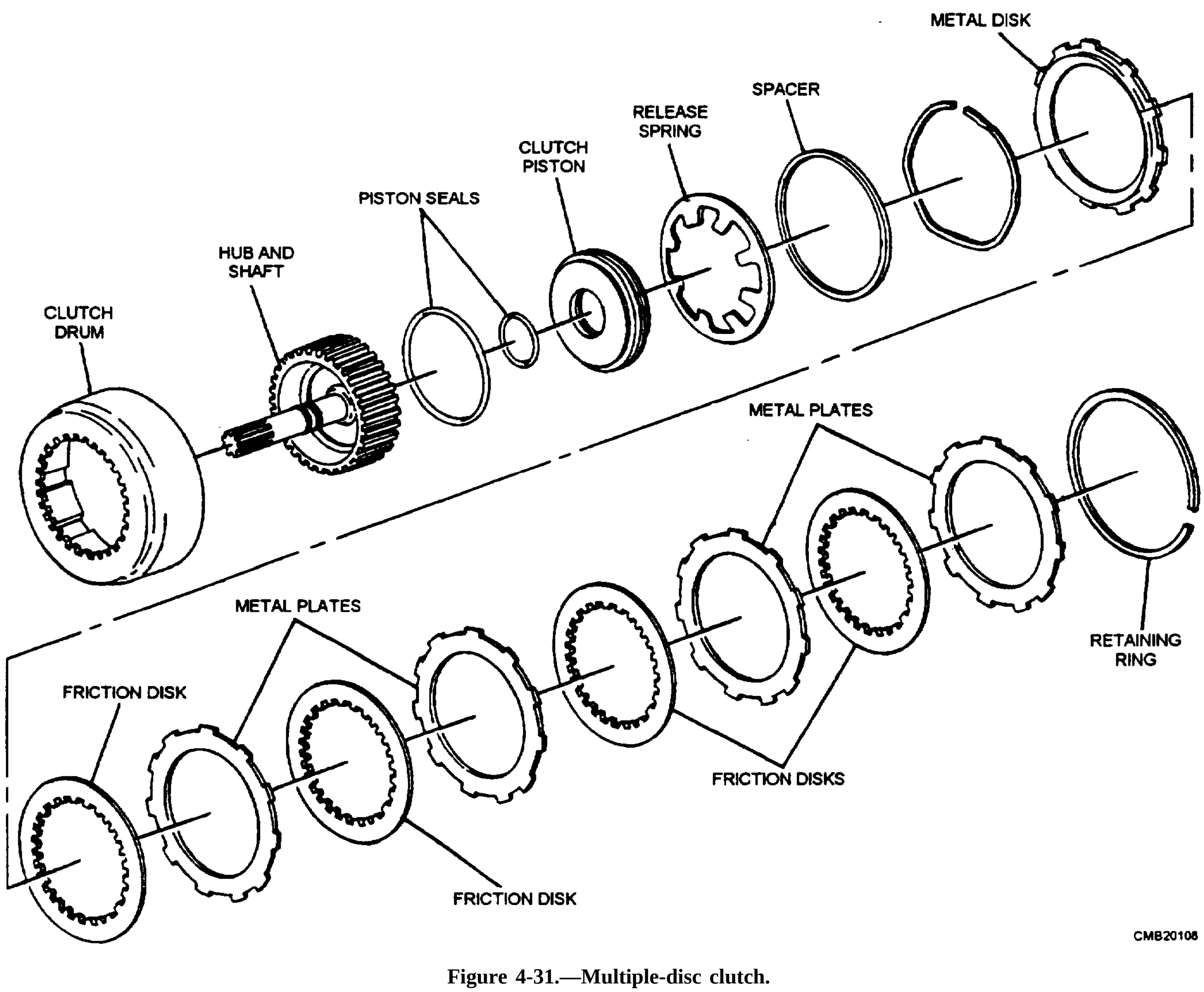

Figure 4-31.—Multiple-disc clutch.

PRESSURE PLATE.—The pressure plates are thick clutch plates that are placed on either end of the stack. Their purpose is to distribute the application pressure equally on the surfaces of the clutch discs and plates.

CLUTCH PISTON.—The clutch piston uses hydraulic pressure to apply the clutch. Hydraulic pressure is supplied to the clutch piston through the center of the rotating member.

CLUTCH PISTON SEALS.—The clutch piston seals serve to prevent the leakage of hydraulic pressure around the inner and outer circumferences of the clutch piston.

CLUTCH SPRINGS.—The clutch springs ensure rapid release of the clutch when hydraulic pressure to the clutch piston is released. The clutch springs may be in the form of several coil springs equally spaced around the piston or one large coil spring that fits in the center of the clutch drum. Some models use a diaphragm-type clutch spring.

The operation of the multiple-disc clutch is as follows (fig. 4-32):

RELEASED—When the clutch is released, there is no hydraulic pressure on the clutch piston and the clutch discs and plates are free to rotate within each other. The result is that the clutch hub rotates freely and does not drive the clutch drum.

APPLIED—When the clutch is applied, hydraulic pressure is applied to the clutch piston that, in turn, applies pressure to the clutch discs and plates, causing them to lock together. The result is that the clutch hub drives the clutch drum through the clutch.

Overrunning Clutch

An **overrunning clutch** is used in automatic transmissions to lock a planetary gearset to the transmission case so that it can act as a reactionary member. The overrunning clutch for the planetary gears is similar to the one in a torque converter stator or an electric starting motor drive gear. A planetary gearset overrunning clutch consists of an inner race, set of springs, rollers, and an outer race.

Operation of the overrunning clutch is very simple to understand. When driven in one direction, rollers lock between ramps on the inner and outer race, allowing both races to turn. This action can be used to stop movement of the planetary member, for example. When turned in the other direction, rollers walk off the ramps, and the races are free to turn independently.

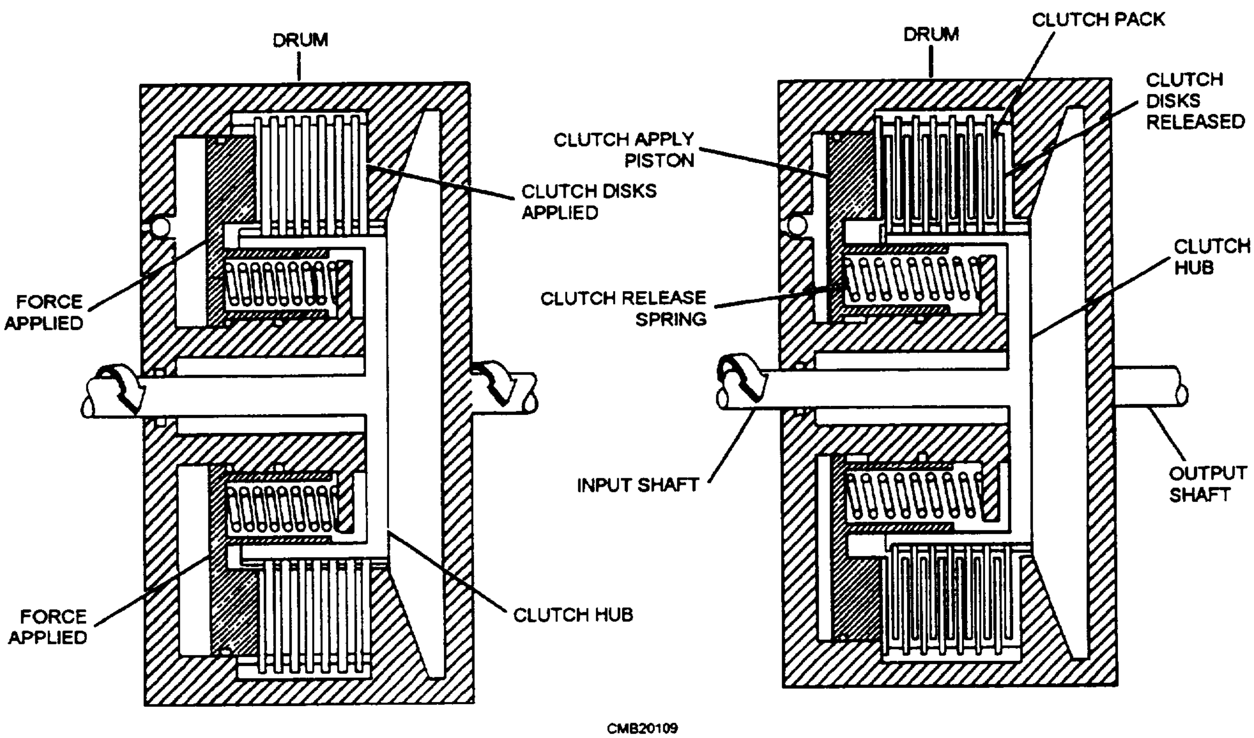

Figure 4-32.—Multiple-disc clutch operation.

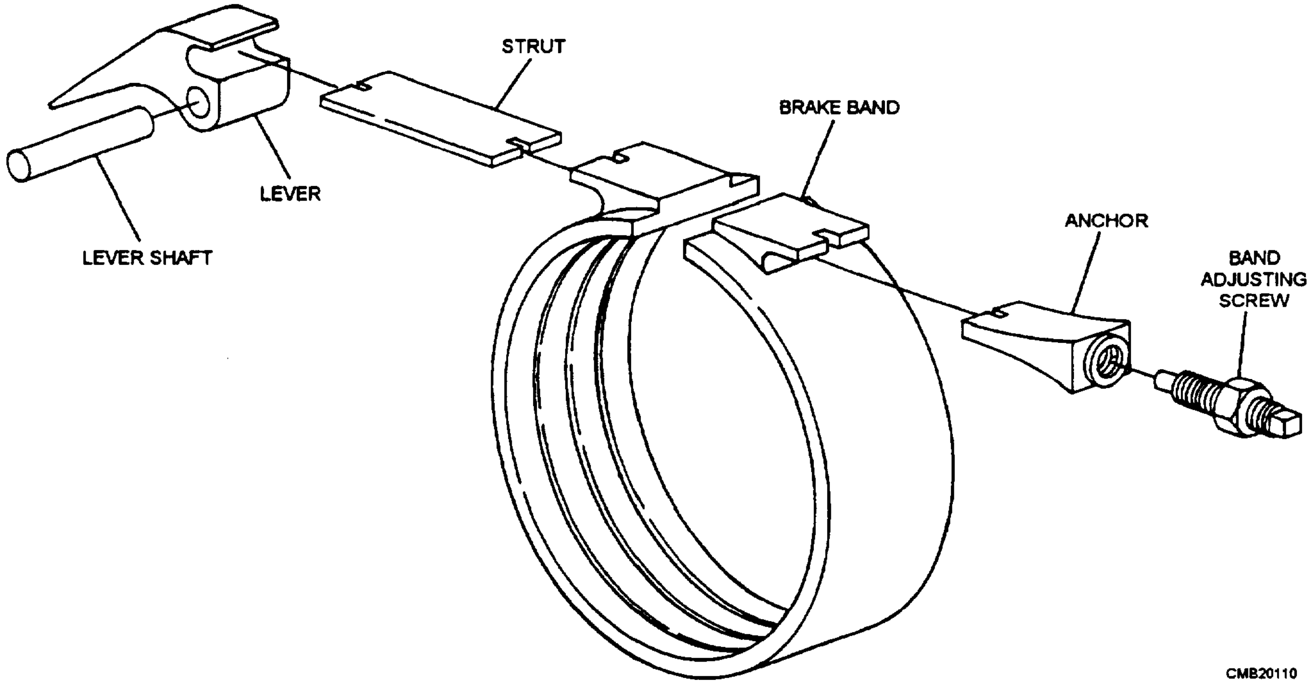

Figure 4-33.—Brake band.

Brake Band

The brake band is used to lock a planetary gearset element to the transmission case so that the element can act as a reactionary member. The brake band is made up of the following elements (fig. 4-33):

BAND.—The brake band is a circular piece of spring steel that is rectangular in cross section. Its inside circumference is lined with a friction material. The brake band has bosses on each end so that it can be held and compressed.

DRUM.—The drum fits inside of the band and attaches to the planetary gear-set element and is to be locked by the band. Its outer surface is machined smoothly to interact with the friction surface of the brake band. By pulling the open ends of the band together, the rotation of the drum stops.

ANCHOR.—The anchor firmly attaches one end of the brake band to the transmission case. A provision for adjusting the clearance between the band and the drum is usually provided on the anchor.

SERVO.—The servo uses hydraulic pressure to squeeze the band around the drum. The servo piston is acted on by hydraulic pressure from the valve body that is fed through an internal passage through the case. The servo piston has a seal around it to prevent leakage of hydraulic pressure and is spring loaded to allow quick release of the band. Some servos use hydraulic pressure on both sides of their pistons so that they use hydraulic pressure for both the release and the application of the band.

The operation of the brake band is as follows (fig. 4-34):

- Released—When the brake band is released, there is no hydraulic pressure applied to the servo, and the drum is free to rotate within the band.

- Applied—When the brake band is applied, hydraulic pressure is applied to the servo that, in turn, tightens the band around the drum. The result is that the drum is locked in a stationary position, causing an output change from the planetary gearset.

In the applied circuit of a clutch or band, an accumulator is used to cushion initial application (fig. 4-35). It temporarily absorbs some of the hydraulic pressure to cause slower movement of the applied piston.

HYDRAULIC SYSTEM

The hydraulic system of an automatic transmission serves four basic purposes:

1. Actuates clutches and brake bands by hydraulic pressure from the hydraulic slave circuits.

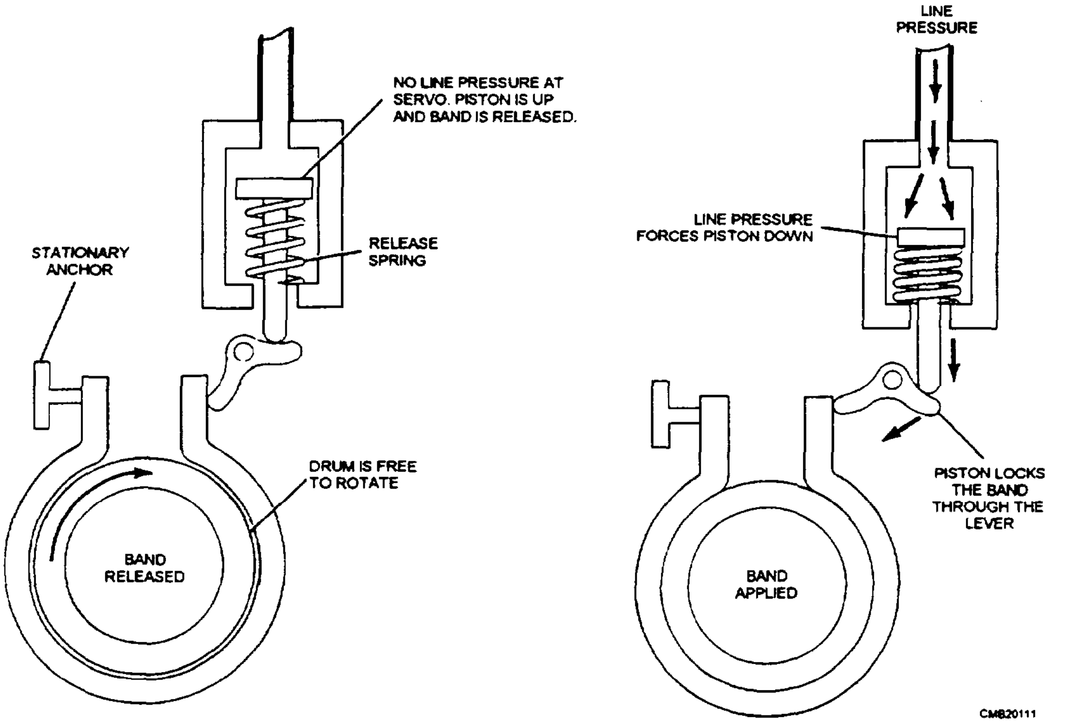

Figure 4-34.—Brake band operation.

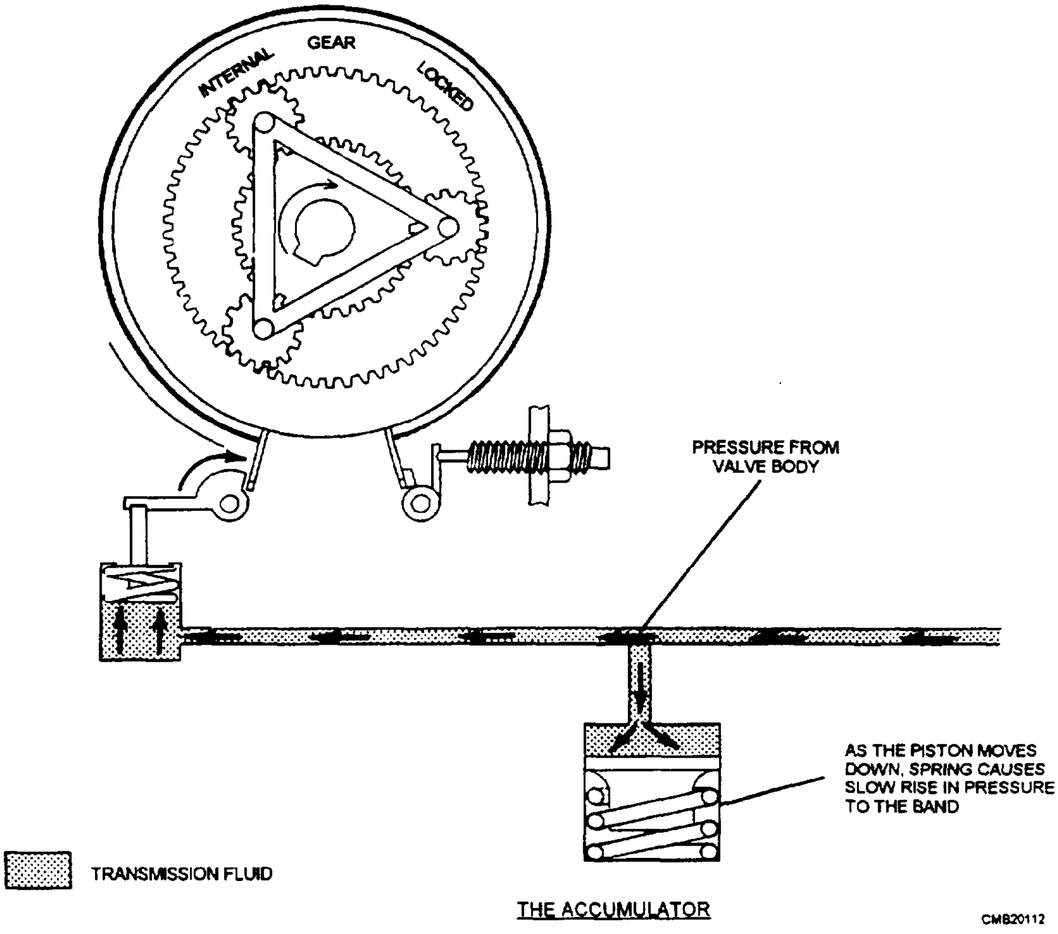

Figure 4-35.—Operation of the accumulator.

2. Controls the shifting pattern ofthetransmission. This is done by switching hydraulic pressure to programmed combinations of clutches and brake bands based on vehicle speed and engine load.

3. Circulates the transmission fluid through a remote cooler to remove excess heat that is generated in the transmission and torque converter.

4. Provides a constant fresh supply of oil to all critical wearing surfaces of the transmission.

The hydraulic system for an automatic transmission typically consists of the following.

Pump

The typical hydraulic pump (fig. 4-36) is an internal-external rotor or gear-type pump. Located in the front of the transmission case, it is keyed to the torque converter hub so that it is driven by the engine. As the torque converter spins the oil pump, transmission fluid is drawn into the pump from the transmission pan. The pump compresses the oil and forces it to the pressure regulator. The pump has several basic functions:

- Produces pressure to operate the clutches, the bands, and the gearsets.
- Lubricates the moving parts in the transmission.
- Keeps the torque converter filled with transmission fluid for proper operation.
- Circulates transmission fluid through the transmission and cooling tank (radiator) to transfer heat.
- Operates hydraulic valves in the transmission.

Pressure Regulator

The pressure regulator limits the maximum amount of oil pressure developed by the oil pump. It is a spring-loaded valve that routes excess pump pressure out of the hydraulic system, assuring proper transmission operation.

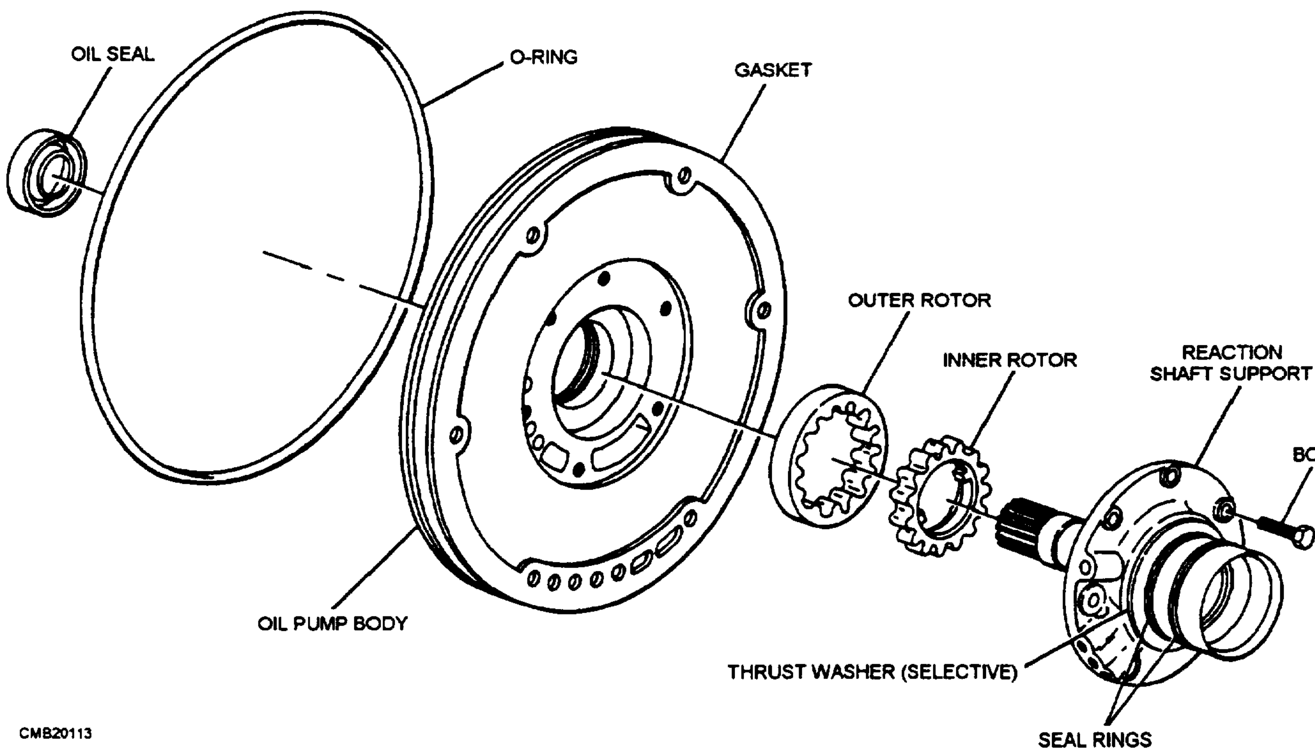

Figure 4-36.—Typical transmission hydraulic pump.

Manual Valve

A manual valve (fig. 4-37), operated by the shift mechanism, allows the operator to select park, neutral, reverse, or different drive ranges. A manual valve is basically a multiport spool valve that switches line pressure to selected passages, as it is moved through its operating positions.

Vacuum Modulator Valve

The vacuum modulator valve (fig. 4-38) is a diaphragm device that uses engine manifold vacuum to indicate engine load to the shift valve. As engine vacuum (load) rises and falls, it moves the diaphragm inside the modulator. This, in turn, moves the rod and hydraulic valve to change throttle control pressure in

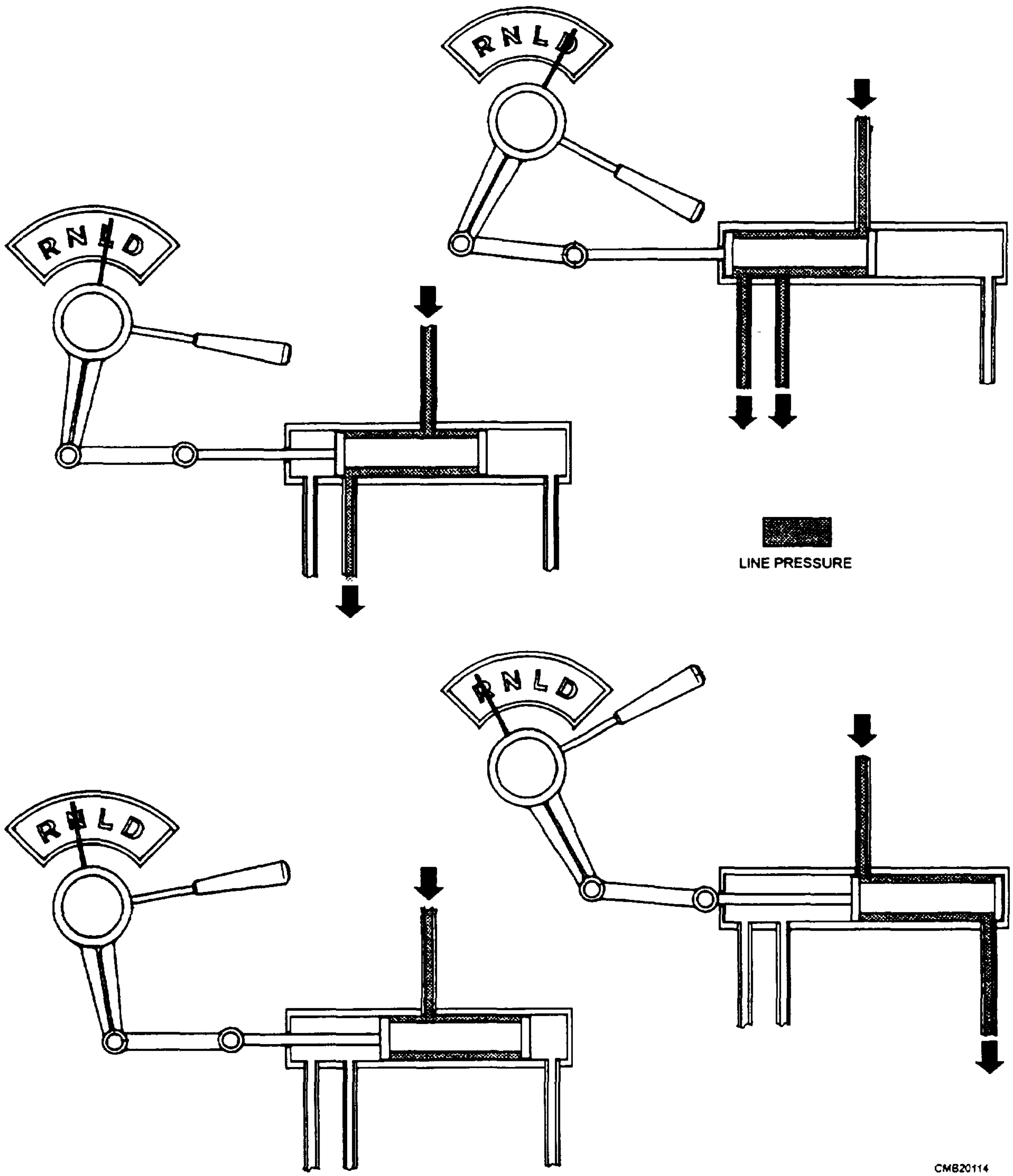

Figure 4-37.—Manual valve operation.

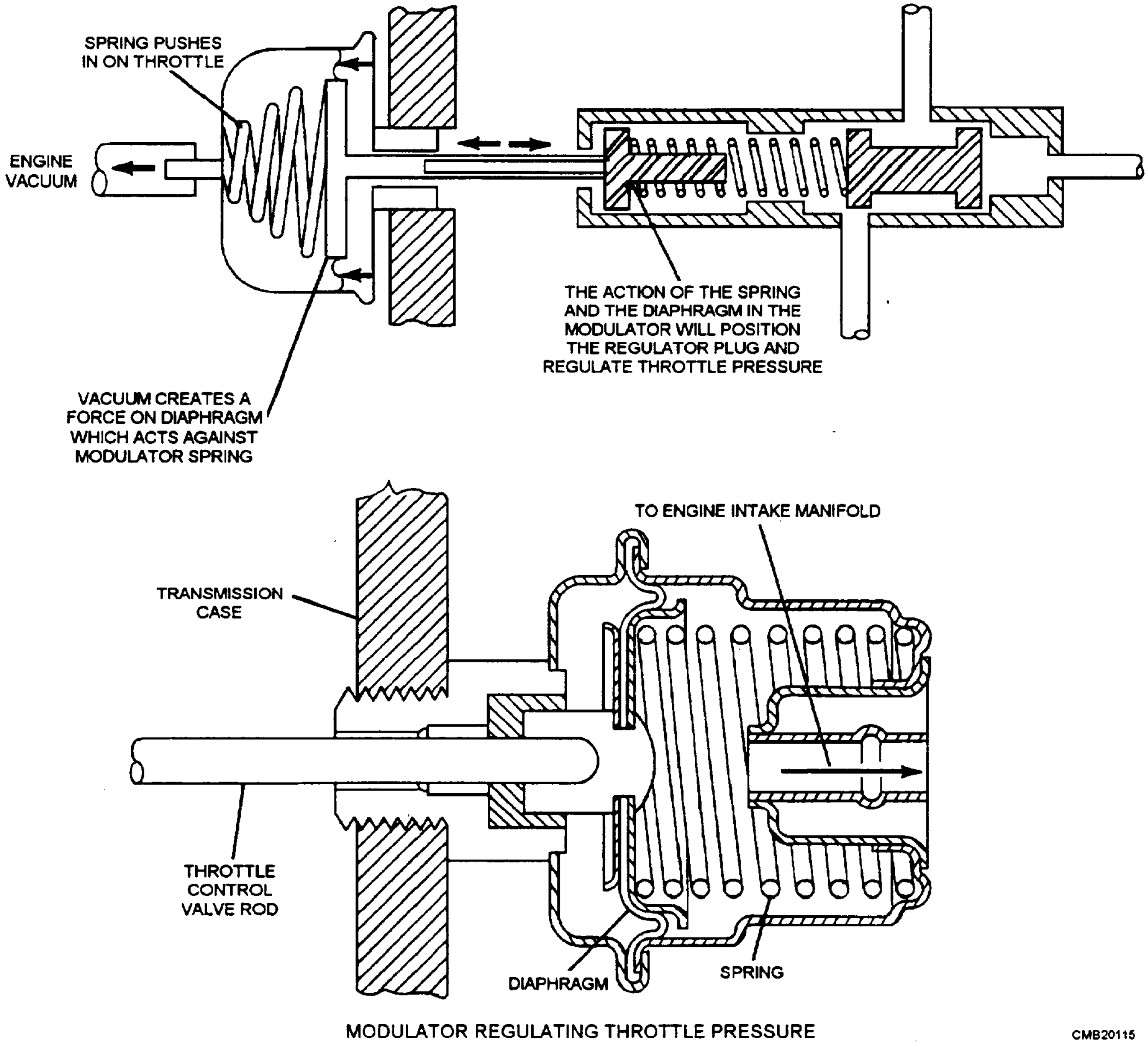

Figure 4-38.—Vacuum modulator valve.

the transmission. In this way, the vacuum modulator can match transmission shift points to engine loads.

Governor Valve

The governor valve (fig. 4-39) senses engine speed (transmission output shaft speed) to help control gear shifting. The vacuum modulator and governor work together to determine shift points. The governor gear is meshed with a gear on the transmission output shaft. Whenever the vehicle and output shaft are moving, the centrifugal weights rotate. When the output shaft and weights are spinning slowly, the weights are held in by the governor springs, causing low-pressure output and the transmission remains in low gear. As the engine speeds increases, the weights are thrown out further and governor pressure increases, moving the shift valve and causing the transmission to shift into higher gear.

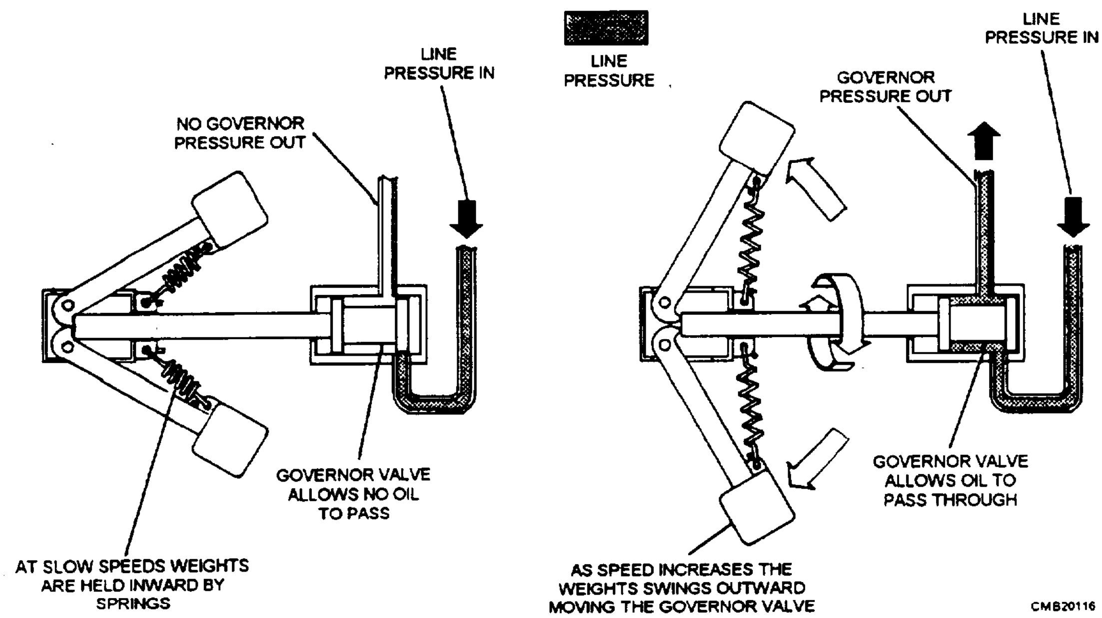

Figure 4-39.—Operation of the governor.

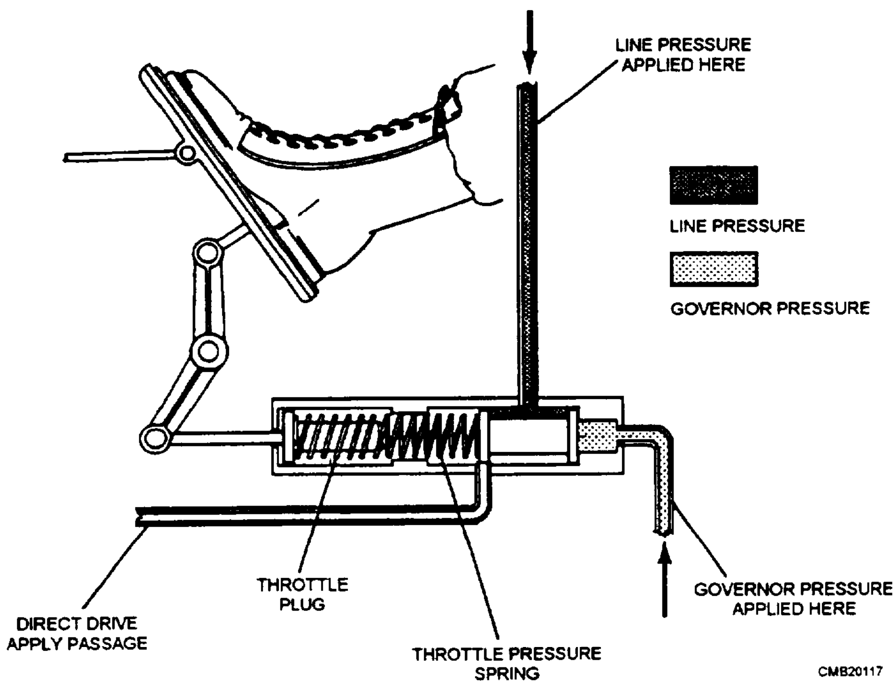

Figure 4-40.—Shift valve.

Shift Valves

The shift valves (fig. 4-40) are simple balance-type spool valves that select between low and high gear when the manual valve is in drive. Using control pressure (oil pressure from the regulator, governor, vacuum modulator, and manual valves), they operate the bands, servos, and gearsets. Oil pressure from the other transmission valves acts on each end of the shift valve. In this way, the shift valve is sensitive to engine load (vacuum modulator valve oil pressure), engine speed (governor valve oil pressure), and gearshift position (manual valve oil pressure). These valves move according to the forces and keep the transmission shifted into the correct gear ratio for the driving conditions.

Kickdown Valve

The kickdown valve causes the transmission to shift into a lower gear during fast acceleration. A rod or cable links the carburetor or fuel injection throttle body to a lever on the transmission. When the operator depresses the throttle, the lever moves the kickdown valve. This action causes hydraulic pressure to override normal shift control pressure and the transmission downshifts.

Valve Body

The valve body contains many of the hydraulic valves, such as the pressure regulator, shift valves, manual valve, and others used in an automatic transmission. The valve body bolts to the bottom of the transmission case and is housed in the transmission pan. A filter or screen is attached to the bottom of the valve body. Passages in the valve body route fluid from the pump to the valves and then into the transmission case. Passages in the transmission case carry fluid to other hydraulic components.

To get an idea of how complicated the hydraulic system really is, a schematic view of an actual hydraulic system for an automatic transmission is shown is figure 4-41.

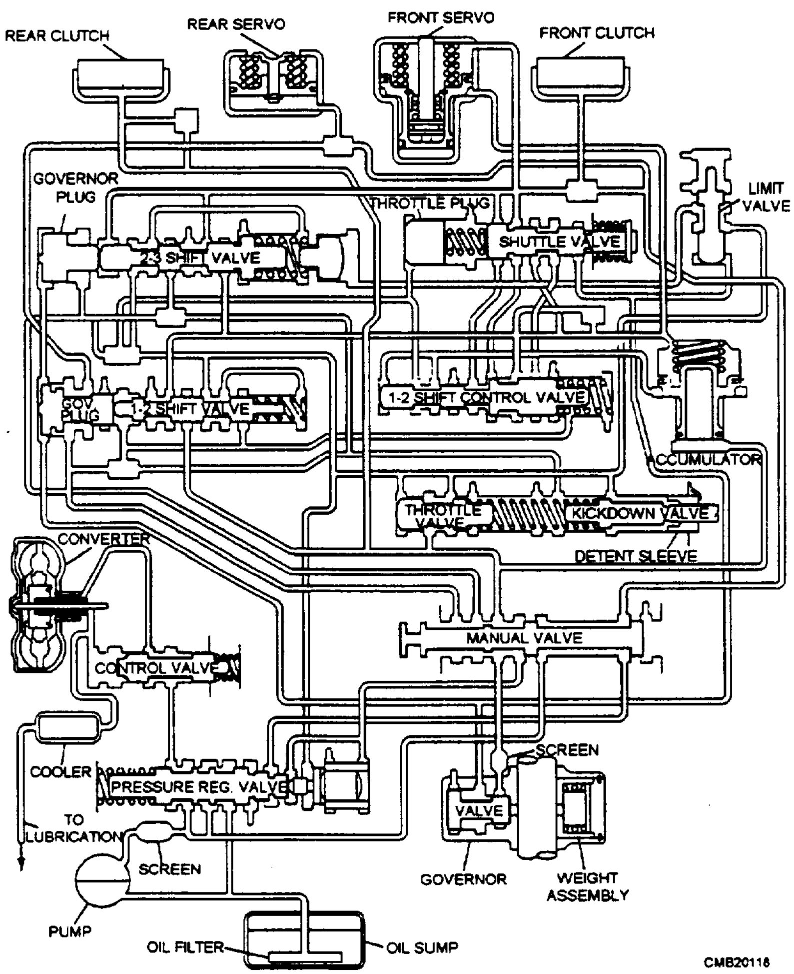

Figure 4-41.—Hydraulic schematic of a typical three-speed automatic transmission.

AUTOMATIC TRANSMISSION SERVICE

Automatic transmission service can be easily divided into the following areas: preventive maintenance, troubleshooting, and major overhaul. Before you perform maintenance or repair on an automatic transmission, consult the maintenance manual for instructions and proper specifications. As a floor mechanic, however, your area of greatest concern is preventive maintenance. Preventive maintenance includes the following:

- Checking the transmission fluid daily
- Adjusting the shifting and kickdown linkages
- Adjusting lockup bands
- Changing the transmission fluid and filter at recommended service intervals

Checking the Fluid

The operator is responsible for first echelon (operator's) maintenance. The operator should not only be trained to know to look for the proper fluid level but also know how to look for discoloration of the fluid and debris on the dipstick.

Fluid levels in automatic transmissions are almost always checked at operating temperature. This is important to know since the level of the fluid may vary as much as three quarters of an inch between hot and cold.

The fluid should be either reddish or clear. The color varies due to the type of fluid. (For example: construction equipment using OE-10 will be clear). A burnt smell or brown coloration of the fluid is a sign of overheated oil from extra heavy use or slipping bands or clutch packs. The vehicle should be sent to the shop for further inspection.

CAUTION

Not all transmission fluids are the same. Before you add fluid, check the manufacturer's recommendations first. The use of the wrong fluid will lead to early internal parts failure and costly overhaul.

Overfilling the transmission can result in the fluid foaming and the fluid being driven out through the vent tube. The air that is trapped in the fluid is drawn into the hydraulic system by the pump and distributed to all parts of the transmission. This situation will cause air to be in the transmission in place of fluid and, in turn, cause slow application and burning of clutch plates and facings. Slippage occurs, heat results, and failure of the transmission follows.

Another possible, but remote, problem is water, indicated by the fluid having a "milky" appearance. A damaged fluid cooling tube in the radiator (automotive) or a damaged oil cooler (construction) could be the problem. The remedy is simple. Pressure-test the suspected components and perform any required repairs. After repairs have been performed, flush and refill the transmission with clean, fresh fluid.

Linkage and Band Adjustment

The types of linkages found on an automatic transmission are gearshift selection and throttle kickdown. The system can be a cable or a series of rod and levers. These systems do not normally present a problem, and preventive maintenance usually involves only a visual inspection and lubrication of the pivot points of linkages or the cable. When adjusting these linkages, you should strictly adhere to the manufacturer's specifications.

If an automatic transmission is being used in severe service, the manufacturer may suggest periodic band adjustment. Lockup bands are always adjusted to the manufacturer's specifications. Bands are adjusted by loosening the locknut and tightening down the adjusting screw to a specified value. The band adjusting screw is backed off a specified amount of turns and the locking nut tightened down. **NOT ALL BANDS ARE ADJUSTABLE.** Always check the manufacturer's service manual before any servicing of the transmission.

Fluid Replacement

Fluid replacement is to be performed according to the manufacturer's recommendations. These recommendations vary considerably for different makes and models. When you change automatic transmission fluid, always read the service manual first.

Service intervals depend on the type of use the vehicle receives. In the NCF, because of the operating environment, more than a few of the vehicles are subjected to severe service. Severe service includes the following: hot and dusty conditions, constant stop and go driving (taxi service), trailer towing, constant heavy hauling, and around the clock operations (contingency). Any CESE operating in these conditions should have its automatic transmission fluid and filter changed on a regular schedule, based on the manufacturer's specifications for severe service. Ensure the vehicle is on level ground or a lift and let the oil drain into a proper catchment device.

The draining of the transmission can be accomplished in one of the following three ways:

1. Removing the drain plug
2. Loosening the dipstick tube
3. Removing the oil pan

CAUTION

Oil drained from automatic transmissions contains heavy metals and is considered hazardous waste and should be disposed of according to local naval station instructions.

Once the oil is drained, remove the pan completely for cleaning by paying close attention to any debris in the bottom of the pan. The presenceofa high amount of metal particles may indicate serious internal problems. Clean the pan; set it aside.

All automatic transmissions have a filter or screen attached to the valve body. The screen is cleanable, whereas the filter is a disposable type and should always be replaced when removed. These are retained in different ways: retaining screws, metal retaining clamps, or O rings made of neoprene. Clean the screen with solvent and use low-pressure air to blow-dry it. Do not use rags to wipe the screen dry, as it tends to leave lint behind that will be ingested into the hydraulic system of the transmission. If the screen is damaged or is abnormally hard to clean, replace it.

Draining the oil from the pan of the transmission does not remove all of the oil—draining the oil from the torque converter completes the process. To do this, remove the torque converter cover and remove the drain plug, if so equipped. For a torque converter with-out a drain plug, special draining instructions may be found in the manufacturer’s service manual. Before performing this operation, clear it with your shop supervisor.

Refilling the Transmission

Reinstall the transmission oil pan, the oil plug, and the fill tube. Fill the transmission with the fluid prescribed by the manufacturer to the proper level. With the brakes applied, start the engine and let it idle for a couple of minutes. Move the gear selectorthrough all gear ranges several times, allowing the fluid to flow through the entire hydraulic system to release any trapped air. Return the selector lever to park or neutral and recheck the fluid level. Bring the fluid to the proper level. Run the vehicle until operating temperature is reached, checking for leaks. Also, recheck the fluid and adjust the level as necessary.

CAUTION

Overfilling an automatic transmission will cause foaming of the fluid. This condition prevents the internal working parts from being properly lubricated, causing slow actuation of the clutches and bands. Eventual burning of the clutches and bands results. DO NOT OVER-FILL AN AUTOMATIC TRANSMISSION.

REVIEW 3 QUESTIONS

Q1. In a vehicle equipped with an automatic transmission, operator control is limited to the selection of the gear range by moving a control lever. (T/F)

Q2. In a torque converter, when does torque multiplication occur?

Q3. What is the purpose of the stator in the torque converter?

Q4. What are the three members of a planetary gearset?

Q5. What is thepurpose of the multiple-disc clutch in an automatic transmission?

Q6. Where is the hydraulic pump of an automatic transmission located?

TRANSAXLES

Learning Objective: Identify components of the manual and automatic transaxles. State the differences between transmissions and transaxles.

A transaxle is a transmission and differential combination in a single assembly. Transaxles are used in front-wheel drive vehicles. A transaxle allows the wheels next to the engine to propel the vehicle. Short drive axles are used to connect the transaxle output to the hubs and drive wheels.

Vehicle manufacturers claim that a transaxle and front-wheel drive has several advantages over a vehicle with rear-wheel drive. A few of these advantages are the following:

- Improved efficiency and reduced drive train weight
- Improved traction on slippery surfaces because of increased weight on the drive wheels
- Increased passenger compartment space (no hump in floorboard for rear drive shaft)
- Less unsprung weight (weight that must move with suspension action), thereby providing a smoother ride
- Quieter operation since engine and drive train noise is centrally located in the engine compartment
- Improved safety because of the increased mass in front of the passengers

Most transaxles are designed so that the engine can be transverse (sideways) mounted in the engine compartment. The transaxle bolts to the rear of the engine. This produces a very compact unit. Engine torque enters the transaxle transmission. The transmission transfers power to the differential. Then the differential turns the drive axles that rotate the front wheels.

Both manual and automatic transaxles are available. Manual transaxle uses a friction clutch and a standard transmission-type gearbox. An automatic transaxle uses a torque converter and a hydraulic system to control gear engagement.

MANUAL TRANSAXLE

A manual transaxle uses a standard clutch and transmission. A foot-operated clutch engages and disengages the engine and transaxle. A hand-operated shift lever allows the operator to charge gear ratios. The basic parts relating to a manual transaxle are as follows:

- Transaxle Input Shaft—main shaft splined to the clutch disc turns the gear in the transaxle.
- Transaxle Input Gears—either freewheeling or fixed gears on the input shaft and meshes with the output gears.
- Transaxle Output Gears—either fixed or freewheeling gears driven by the input gears.
- Transaxle Output Shaft—transfers torque to the ring gear, pinion gears, and differential.
- Transaxle Synchronizers—splined hub assemblies that can lock freewheeling gears to their shafts for engagement.
- Transaxle Differential—transfers gearbox torque to the driving axle and allows the axles to turn at different speeds.
- Transaxle Case—aluminum housing that encloses and supports parts of the transaxle.

The manual transaxle can be broken up into two separate units—a manual transaxle transmission and a transaxle differential. A manual transaxle transmission provides several (usually four or five) forward gears and reverse. You will find that the names of shafts, gears, and other parts in the transaxle vary, depending on the location and function of the components. For example, the input shaft may also be called the main shaft, and the output shaft is called the pinion shaft because it drives the ring and pinion gear in the differential. The output, or pinion, shaft has a gear or sprocket for driving the differential ring gear.

The clutch used on the manual transaxle transmission is almost identical to the manual transmission clutch for rear-wheel drive vehicles. It uses a friction disc and spring-loaded pressure plate bolted to the flywheel. Some transaxles used a conventional clutch release mechanism (release bearing and fork); others use a long pushrod passing through the input shaft.

The transaxle differential, like a rear axle differential, transfers power to the axles and wheels while allowing one wheel to turn at a different speed than the other. A small pinion gear on the gearbox output shaft or countershaft turns the differential ring gear. The ring gear is fastened to the differential case. The case holds the spider gears (pinion gears and axle side gears) and a pinion shaft. The axle shafts are splined to the differ-ential side gears.

AUTOMATIC TRANSAXLE

An automatic transaxle is a combination automatic transmission and differential combined into a single assembly. The basic parts of an automatic transaxle are as follows:

- Transaxle Torque Converter—(fluid-type clutch that slips at low speed but locks up and transfers engine power at a predetermined speed; couples and uncouples engine crankshaft to transmission input shaft and gear train).

- Transaxle Oil Pump—(produces hydraulic pressure to operate, lubricate, and cool the automatic transaxle; its pressure activates the pistons and servos).

- Transaxle Valve Body—(controls the flow of the fluid to the pistons and servos in the transaxle; it contains hydraulic valves operated by the operators shift linkage and by engine speed and load-sensing components).

- Transaxle Pistons and Servos—(operates the clutches and bands when activated by fluid pressure from the valve body).

- Transaxle Clutches and Bands—(applies planetary gears in the transaxle; different bands and clutches are activated to operate different units in the gear-sets).

- Transaxle Planetary Gearsets—(provides different gear ratios and reverse in the automatic transaxle).

- Transaxle Differential—(transfers powers from the transmission components to the axle shafts).

Many of the components used in the automatic transaxle are also found in the automatic transmission. Operating principles of these components are the same as the automatic transmission. The differential of the automatic transaxle is similar to that used on the manual transaxle.

REVIEW 4 QUESTIONS

Q1. What is the purpose of the output shaft of a manual transaxle?

Q2. In an automatic transaxle, what component(s) operate(s) the clutches and bands?

REVIEW 1 ANSWERS

Q1. *Connects anddisconnects the engine and manual transmission or transaxle*

Q2. *Clutch release mechanism*

Q3. *Clutch fork*

Q4. *Torsion spring*

Q5. *Clutch start switch*

Q6. *1 1/2 inch*

REVIEW 2 ANSWERS

Q1. *Aluminum*

Q2. *Input shaft, countershaft, reverse idler shaft, and main shaft*

Q3. *Locks the main shaft gear to the main shaft and prevents the gears from clashing during shifting*

Q4. *External rod and internal shift rail*

Q5. *Industrial and farm equipment*

Q6. *7.55 to 1*

REVIEW 3 ANSWERS

Q1. *True*

Q2. *When the impeller is spinning faster than the turbine*

Q3. *Redirects oil returning from the turbine and changes its rotation back to that of the impeller*

Q4. *Sun gear, ring gear, and planetary carrier*

Q5. *To transmit torque by locking elements of the planetary gearset to rotating members within the transmission*

Q6. *Located in the front of the transmission case and keyed to the torque converter hub*

REVIEW 4 ANSWERS

Q1. *Transfer torque to the ring gear, the pinion gears, and the differential*

Q2. *Transaxle pistons and servos*